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# **An Investigation of Post-Primary Students' Images of Mathematics**

By

Ciara Mary Frances Lane

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Sciences

Head of Department: Prof. Bernard Hanzon

Supervisors: Prof. Martin Stynes (UCC), Prof. John O'Donoghue (UL)  
and Dr. Tom Carroll (UCC)

## Table of Contents

<b>DECLARATION.....</b>	<b>V</b>
<b>ABSTRACT .....</b>	<b>VI</b>
<b>DEDICATION.....</b>	<b>VIII</b>
<b>ACKNOWLEDGEMENTS.....</b>	<b>IX</b>
<b>LIST OF TABLES .....</b>	<b>X</b>
<b>LIST OF FIGURES .....</b>	<b>XI</b>
<b>LIST OF APPENDICES .....</b>	<b>XI</b>
<b>CHAPTER ONE: INTRODUCTION .....</b>	<b>1</b>
SECTION 1.1: BACKGROUND TO RESEARCH AND SIGNIFICANCE OF RESEARCH.....	3
SECTION 1.2: RESEARCH SAMPLE .....	5
SECTION 1.3: LIMITATIONS OF THE STUDY .....	6
SECTION 1.4: THE RESEARCH PROBLEM AND AIMS OF THE RESEARCH.....	7
SECTION 1.5: RESEARCH QUESTIONS .....	7
SECTION 1.6: OUTLINE OF THESIS .....	10
SECTION 1.7: DESCRIPTION OF TERMS USED THROUGHOUT THE THESIS .....	12
<b>CHAPTER TWO: LITERATURE REVIEW .....</b>	<b>14</b>
2.1 LITERATURE ON IMAGE OF MATHEMATICS .....	15
2.2 LITERATURE ON ATTITUDES TOWARDS MATHEMATICS.....	23
2.3 LITERATURE ON BELIEFS ABOUT MATHEMATICS .....	30
2.4 LITERATURE ON SELF-CONCEPT IN MATHEMATICS.....	39
2.5 LITERATURE ON EMOTIONS TOWARD MATHEMATICS .....	41
2.6 LITERATURE ON PAST EXPERIENCES AND FACTORS OF INFLUENCE .....	45
2.7 SUMMARY .....	51
<b>CHAPTER THREE: THEORETICAL FRAMEWORK FOR IMAGE OF MATHEMATICS.....</b>	<b>53</b>
3.1 DEFINITION OF ‘IMAGE’ .....	54
3.2 DEFINITION OF ‘MATHEMATICS’ .....	55
3.3 DEFINITION OF ‘IMAGE OF MATHEMATICS’ .....	56
3.4 THE AFFECTIVE, COGNITIVE AND CONATIVE DOMAINS.....	59
3.5 SUMMARY OF THEORETICAL FRAMEWORK .....	64
3.6 RESEARCH QUESTIONS.....	67
<b>CHAPTER FOUR: METHODOLOGY .....</b>	<b>69</b>
4.1 RESEARCH DESIGN.....	70
4.2 METHODOLOGY – A MIXED-METHODS APPROACH .....	75
4.3 METHODS .....	80

4.4 SAMPLING METHODOLOGY .....	93
4.5 VALIDITY AND RELIABILITY .....	101
4.6 ETHICS .....	103
4.7 RESEARCHER DISTANCE.....	105
4.8 SUMMARY .....	105
<b>CHAPTER FIVE: THE PILOT STUDY – TESTING THE RESEARCH INSTRUMENT.....</b>	<b>106</b>
5.1 PURPOSE OF THE PILOT STUDY .....	107
5.2 SECTION A .....	110
5.3 SECTION B.....	117
5.4 COMMENTS .....	120
5.5 SUMMARY .....	122
<b>CHAPTER SIX: EXAMINING STUDENTS’ IMAGE OF MATHEMATICS; ANALYSIS OF THE QUANTITATIVE DATA.....</b>	<b>127</b>
SECTION 6.1: STUDENT PROFILE .....	129
SECTION 6.2: SECTION B .....	137
SECTION 6.3: RELIABILITY OF SCALES .....	149
SECTION 6.4: ANALYSIS PERFORMED BY SCALE AUTHORS.....	153
SECTION 6.5: FURTHER ANALYSIS .....	157
SECTION 6.6: SUMMARY .....	186
<b>CHAPTER SEVEN: A FURTHER LOOK AT STUDENTS’ IMAGES OF MATHEMATICS: ANALYSIS OF THE QUALITATIVE DATA .....</b>	<b>191</b>
SECTION 7.1 PARENTS’ OCCUPATION.....	192
SECTION 7.2: QUESTION 1 .....	195
SECTION 7.3: QUESTION 2 .....	199
SECTION 7.4: QUESTION 3 .....	204
SECTION 7.5: QUESTION 4.....	208
SECTION 7.6: QUESTION 5 .....	213
SECTION 7.7: QUALITATIVE ANALYSIS .....	217
SECTION 7.8: SUMMARY .....	241
<b>CHAPTER EIGHT: WHAT IS THE IMAGE OF MATHEMATICS HELD BY POST-PRIMARY STUDENTS IN IRELAND? A DISCUSSION ON FINDINGS FROM THE QUANTITATIVE AND QUALITATIVE DATA ANALYSIS ....</b>	<b>243</b>
SECTION 8.1: ADDRESSING THE RESEARCH QUESTIONS (PART A) .....	244
SECTION 8.2: ADDRESSING THE RESEARCH QUESTIONS (PART B) .....	255
SECTION 8.3: STUDENTS’ IMAGES OF MATHEMATICS .....	264
SECTION 8.4: GENDER DIFFERENCES IN STUDENTS’ IMAGES OF MATHEMATICS....	267
SECTION 8.5: ISSUES CONCERNING THE CURRENT NATIONAL INTEREST IN MATHEMATICS .....	270
SECTION 8.6: PARENTS’ OCCUPATION.....	274
SECTION 8.7 SUMMARY .....	275
<b>CHAPTER NINE: CONCLUSIONS, RECOMMENDATIONS AND FUTURE RESEARCH .....</b>	<b>277</b>

SECTION 9.1: SUMMARY OF THESIS .....	278
SECTION 9.2: CONCLUSIONS AND CONTRIBUTIONS .....	284
SECTION 9.3: IMAGE OF MATHEMATICS MODEL .....	289
SECTION 9.4: RECOMMENDATIONS .....	290
SECTION 9.5: FUTURE RESEARCH.....	292
<b>APPENDICES .....</b>	<b>293</b>
APPENDIX A.....	294
APPENDIX B .....	305
APPENDIX C .....	306
APPENDIX D.....	307
BIBLIOGRAPHY.....	309

## **Declaration**

This thesis is entirely my own work and has not been submitted for any other degree, either at University College Cork or any other institution.

**Signed:** \_\_\_\_\_

**Date:** \_\_\_\_\_

## **Abstract**

This research study investigates the image of mathematics held by 5<sup>th</sup>-year post-primary students in Ireland. For this study, “image of mathematics” is conceptualized as a mental representation or view of mathematics, presumably constructed as a result of past experiences, mediated through school, parents, peers or society. It is also understood to include attitudes, beliefs, emotions, self-concept and motivation in relation to mathematics. This study explores the image of mathematics held by a sample of 356 5<sup>th</sup>-year students studying ordinary level mathematics. Students were aged between 15 and 18 years. In addition, this study examines the factors influencing students’ images of mathematics and the possible reasons for students choosing not to study higher level mathematics for the Leaving Certificate.

The design for this study is chiefly explorative. A questionnaire survey was created containing both quantitative and qualitative methods to investigate the research interest. The quantitative aspect incorporated eight pre-established scales to examine students’ attitudes, beliefs, emotions, self-concept and motivation regarding mathematics. The qualitative element explored students’ past experiences of mathematics, their causal attributions for success or failure in mathematics and their influences in mathematics.

The quantitative and qualitative data was analysed for all students and also for students grouped by gender, prior achievement, type of post-primary school attending, co-educational status of the post-primary school and the attendance of a Project Maths pilot school.

Students’ images of mathematics were seen to be strongly indicated by their attitudes (enjoyment and value), beliefs, motivation, self-concept and anxiety, with each of these elements strongly correlated with each other, particularly self-concept and anxiety. Students’ current images of mathematics were found to be influenced by their past experiences of mathematics, by their mathematics teachers, parents and peers, and by their prior mathematical achievement. Gender differences occur for students in their images of mathematics, with males having more positive images of

mathematics than females and this is most noticeable with regards to anxiety about mathematics. Mathematics anxiety was identified as a possible reason for the low number of students continuing with higher level mathematics for the Leaving Certificate. Some students also expressed low mathematical self-concept with regards to higher level mathematics specifically. Students with low prior achievement in mathematics tended to believe that mathematics requires a natural ability which they do not possess. Rote-learning was found to be common among many students in the sample. The most positive image of mathematics held by students was the “problem-solving image”, with resulting implications for the new Project Maths syllabus in post-primary education.

Findings from this research study provide important insights into the image of mathematics held by the sample of Irish post-primary students and make an innovative contribution to mathematics education research. In particular, findings contribute to the current national interest in Ireland in post-primary mathematics education, highlighting issues regarding the low uptake of higher level mathematics for the Leaving Certificate and also making a preliminary comparison between students who took part in the piloting of Project Maths and students who were more recently introduced to the new syllabus. This research study also holds implications for mathematics teachers, parents and the mathematics education community in Ireland, with some suggestions made on improving students’ images of mathematics.



## **Dedication**

I would like to dedicate my thesis to my family – to my parents, Mary and Jerry, and my sister Hannah. Thank you for your continual support and encouragement without which I would not have been able to complete this study. Your belief in me allowed me to fulfil my own expectations.

Above all, I dedicate my work to my wonderful son Joshua who gave me an extra special reason for achieving my goals. Josh, you fill my life with laughter and love. You are my world.

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## List of Tables

Table 1.1: Image of Mathematics Scales .....	9
Table 2.1: Attitude Dimensions .....	25
Table 2.2: Habermas' (1972) Three Domains of Knowledge .....	35
Table 4.1: Knowledge claims, strategies of inquiry and methods leading to approaches and the design process (Creswell, 2003).....	74
Table 4.2: Mixed Methods Employed in This Study .....	80
Table 4.3 Co-educational Status of Post-primary Schools .....	96
Table 4.4 Distribution of Post-primary Students in Post-primary School Categories .....	97
Table 4.5: Selected Sample of Schools .....	100
Table 5.1: Cronbach Alpha Values for Section B Scales.....	118
Table 5.2: Mean Total Scores for Section B Scales.....	120
Table 6.1 Gender of Students.....	130
Table 6.2: Co-educational status of Post-primary School Categories .....	132
Table 6.3: Junior Certificate Mathematics Level.....	133
Table 6.4: Junior Certificate Mathematics Grade .....	133
Table 6.5: Sub-Categories of Junior Certificate Mathematics Grade .....	135
Table 6.6: Project Maths Pilot School .....	136
Table 6.7: Item statistics (Number Responses, Mean and Standard Deviation).....	144
Table 6.8: Scale Mean, Standard Deviation, Variance and Number of Respondents .....	146
Table 6.9: Scale Means and Standard Deviation by Gender.....	149
Table 6.10: Reliability of Scales .....	150
Table 6.11: Variance for Fennema-Sherman Scales by Gender .....	155
Table 6.12: Pearson's Correlations.....	159
Table 6.13: Mann-Whitney U Test - Gender .....	176
Table 6.14: Mann-Whitney U Test - Single-sex Girls' Schools .....	176
Table 6.15: Mann-Whitney U Test - Higher Level Grade A with Others .....	178
Table 6.16: Mann-Whitney U Test - Ordinary Level Grade C with Others .....	179
Table 6.17: Independent Samples T-Test - Gender .....	182
Table 6.18: One-Way Between-Groups ANOVA - Co-educational Status.....	184
Table 6.19: One-Way Between-Groups ANOVA - Type of Post-Primary School ..	184
Table 6.20: Summary of Findings from Qualitative Data.....	190
Table 7.1: Correlations for Parent(s)' Occupation with Student Profile Variables ..	193
Table 7.2: Section A: Question 1 - Frequency.....	195
Table 7.3: Pearson's Correlation for Section A Question 1 re-coded with Image of Mathematics Scales .....	197
Table 7.4: Median Scores for Question1recode on Image of Mathematics Scales...	198
Table 7.5: Frequencies for Section A Question 2 (a).....	200
Table 7.6: Frequencies for Section A Question 2 (b).....	201
Table 7.7: Pearson Correlation for Question2brecode with Image of Mathematics Scales.....	204
Table 7.8: Frequencies for Section A Question 3(b).....	207
Table 7.9: Frequencies for Section A Question 4(b).....	211

Table 7.10: Pearson Correlation for Question 5(a) with Image of Mathematics Scales .....	214
Table 7.11: Frequencies for Section A Question 5(b).....	215

## List of Figures

Figure 2.1: Autonomous Learning Behaviours .....	37
Figure 3.1: Image of Mathematics .....	58
Figure 3.2: Theoretical Background for 'Image of Mathematics' .....	66
Figure 4.1 The Classical Research Cycle/ The Scientific Method (from Leedy & Ormrod, 2001).....	72
Figure 9.1: Image of Mathematics Model.....	289

## List of Appendices

<b>APPENDIX A - STUDENT QUESTIONNAIRE .....</b>	<b>294</b>
<b>APPENDIX B - COVER LETTER.....</b>	<b>305</b>
<b>APPENDIX C - DEBRIEF LETTER.....</b>	<b>306</b>
<b>APPENDIX D - PARENT/GUARDIAN INFORMATION SHEET AND INFORMED CONSENT FORM.....</b>	<b>307</b>

# **Chapter One**

## **Introduction**

## Chapter One: Introduction

Affective and cognitive issues regarding mathematics and mathematics education have come to the fore of mathematics education research in recent years. This aspect of mathematics education have been examined in Ireland and abroad, with studies by McLeod (1992), Kelly & Oldham (1992), Brown (1995), Ernest (1996) and Lim (1999) (to name but a few) establishing a strong theoretical basis for examining the relationship between affective and/or cognitive issues and mathematics. Later studies such as Tait-McCutcheon (2008), Hill (2008), Eaton & O'Reilly (2009), Liston & O'Donoghue (2007, 2009) and Wilson (2011) further developed theoretical frameworks regarding affect and/or cognition in mathematics education. These research studies examined the relationships between affect/cognition in mathematics education and the impact on primary school students, post-primary school students, third-level (higher education) students, student teachers and mathematics teachers.

While some researchers concentrated on a particular aspect of affect or cognition such as attitudes (affect) or beliefs (cognition), other researchers considered affective issues or cognitive issues in general. A selection of research studies examined both affective and cognitive issues in relation to mathematics education, and in some cases, a third concern was included – conative issues (dealing with behavioural intent or motivation). Studies that incorporated both affective and cognitive issues (and in some cases conative issues) defined the combined issues as “*mathematical identity*” (Hill, 2008; Eaton & O'Reilly, 2009), “*self-efficacy*” (Tait-McCutcheon, 2008), “*disposition*” (Wilson, 2011) or “*image of mathematics*” (Burton, 1989; Kelly & Oldham, 1992; Brown, 1995; Ernest, 1996; Lim, 1999).

In this thesis, we aim to examine affective, cognitive and conative issues in mathematics education, and adopt the term “*image of mathematics*” to address these issues. The affective, cognitive and/or conative aspects of mathematics education have not previously been examined extensively in Ireland in relation to post-primary school students. Thus we identified an obvious gap in mathematics education

research in the Irish context. Therefore, this PhD research study will examine the image of mathematics held by post-primary school students in Ireland.

### ***Section 1.1: Background to Research and Significance of Research***

Mathematics is the life-blood of any society. It has a vital role in everyday life in our homes, schools and workplaces. The National Council for Curriculum and Assessment (NCCA, 2005) acknowledged that learning mathematics transforms our ability to conceptualise and structure relationships; it gives us a tool to model our world and therefore enables us to both control and change it. The general public's view of mathematics, whether in Ireland or elsewhere, often depends on their experience of mathematics, particularly during school years. This dependence is supported by Lim (1999) who found in her study of the public image of mathematics in the UK that most people did not distinguish between their image of mathematics and their image of learning mathematics. Therefore the process of teaching and learning mathematics plays a vital role in establishing a person's image of mathematics. Mathematics education researchers have come to realise in recent years the significance of students' attitudes, beliefs, emotions, motivation and self-concept regarding mathematics, with consequential effects on mathematical performance and achievement.

In Ireland, mathematics is effectively a compulsory subject in post-primary education and is studied by approximately 94% of Leaving Certificate students each year (Spotlight, 2009). There has been a general acceptance in Ireland for many years that current mathematics education in our post-primary schools is insufficient. Also of concern is that post-primary students are not being equipped with the skills required by society and in particular the mathematical tools essential for understanding the modern world. Internationally there are also many concerns about the state of mathematics education. These concerns involve two sets of factors, namely "push" (poor levels of understanding and achievement gaps) and "pull" (the need for 21<sup>st</sup> century skills) factors (Conway & Sloane, 2006, p.13). The "push" factor is mainly concerned with low levels of understanding of mathematics and an

inability to apply mathematics in practical real-world contexts, as well as achievement gaps between boys and girls, between different ethnic groups and between different countries. According to the NCCA (2005, p.15), the Programme for International Student Assessment (PISA) 2003 results demonstrated that Irish students were unfamiliar with the placing of mathematical problems in a real-life setting. Students who learn mathematics in a routine, inflexible, abstract and procedural environment, attempt to solve problems in a routine fashion, disregarding contextual information (Conway & Sloane, 2006, p.14). This is an after-effect of the rote-learning system that is commonly used in Ireland.

The purpose of post-primary education according to Gardner (2004, p.214) is to help “*students obtain fluency in the basic literacies, so that they can deal readily with all manner of texts, assisting them in mastering the fundamentals of several key disciplines, particularly mathematics and the sciences, and provide tools so that students can understand and participate in the formal and informal social, economic and political systems of their country*”. With ever-increasing globalization, education policy makers are identifying the new skills essential for students in order to prepare them to live in this century’s “knowledge society”: the “pull” factor (Conway & Sloane, 2006, p.19). Gardner identifies the knowledge, skills and dispositions required in pre-collegiate education (post-primary education which prepares students for further study in a college or university) in this era of globalization as:

- The ability to think analytically and creatively within disciplines.
- The ability to tackle problem issues that do not respect disciplinary boundaries.

In relation to mathematics, the ability to think analytically and creatively and to tackle problems is particularly relevant. As this PhD study began, a phased introduction of a new mathematics curriculum for post-primary schools, Project Maths, was under way. The new Project Maths curriculum claims that students will



*“learn to apply their mathematical knowledge and skills, develop confidence in their own ability to ‘do’ mathematics and lay a foundation that will enable them to follow a broader range of courses and careers, including those which involve mathematics”.*

The current interest in innovation and change in mathematics education in Ireland and the relevance of affective, cognitive and conative issues to the mathematics education community both in Ireland and abroad provide strong motivation for this PhD study. This thesis is the first large-scale study investigating the image of mathematics held by post-primary students in Ireland. It is expected that the findings from our research will provide systematic and empirical data on post-primary students’ images of mathematics. These findings will also help researchers to understand better the role of past experience, teachers, family, peers and society in influencing students’ images of mathematics. As the findings will hold implications for mathematics education and mathematics teacher education, it is hoped that our research will help to develop better teacher development programmes.

## **Section 1.2: Research Sample**

Investigating the image of mathematics held by post-primary students in Ireland is a research gap within mathematics education. In particular, we were interested in examining students in the Leaving Certificate cycle of post-primary school. Leaving Certificate cycle students have experienced at least 3 years of post-primary education and therefore it is hypothesized that they will have formed a stronger image of mathematics than students who are in their first years of post-primary education. Two sets of students are involved in the Leaving Certificate cycle – 5<sup>th</sup>-year students and 6<sup>th</sup>-year students. As 6<sup>th</sup>-year students are in the process of preparing for the Leaving Certificate examinations and consequently their teachers and parents may be less inclined to allow participation in our survey, it was decided to look at the image of mathematics held by 5<sup>th</sup>-year post-primary students. (These students tend to be between 15 and 18 years old). In addition, we decided to focus on ordinary-level mathematics students as these students would provide information regarding the cohort of students who had previously studied higher-level mathematics

for the Junior Certificate but had chosen to study ordinary level mathematics for the Leaving Certificate. The large number of students discontinuing with higher level mathematics for the Leaving Certificate is a major concern for mathematics education in Ireland and thus our study would also address this issue.

The research population for this PhD study would thus comprise all 5<sup>th</sup>-year post-primary school students studying ordinary level mathematics in the Republic of Ireland, approximately 34,577 students (see Section 4.4). The sampling methodology employed in our study follows a methodology similar to that used by the Economic and Social Research Institute (Murray et al., 2011) in their study *Growing up in Ireland* in which a representative random sample of nine-year olds was selected. In our study, we chose a representative random sample of ordinary level mathematics 5<sup>th</sup>-year students. The type of post-primary school attended, the co-educational status of the post-primary school attended and the school ethos (fee-paying or non-fee-paying) were all considerations when selecting our sample of students. Our aim was to survey 400 students in 5<sup>th</sup> year post-primary school. The actual number of students who took part in our study was 356. While this was slightly below our aim of 400 students, the number of participants was still adequate for our purposes; in making our study representative of 5<sup>th</sup>-year post-primary students and providing innovative findings regarding the image of mathematics held by post-primary students in Ireland. The sampling methodology used in our study is discussed in detail in Section 4.4 of this thesis.

### ***Section 1.3: Limitations of the Study***

We recognise that our research study is focused on students in 5<sup>th</sup> year of post-primary school in Ireland and is oriented to the Western world from which much of the theoretical background to our study is developed. We also recognise limitations to our research study as a result of the sampling methodology employed and possible researcher bias. The limitations of our research study are discussed in more detail in Chapter Four.

## **Section 1.4: The Research Problem and Aims of the Research**

The research problem is to investigate the image of mathematics held by 5<sup>th</sup>-year post-primary students in Ireland. The primary aims of our research study are:

1. To review the literature relating to image of mathematics including attitudes, beliefs, emotions, self-concept and motivation regarding mathematics as well as the literature regarding influences on the formation of an image of mathematics.
2. To design and implement a questionnaire survey consisting of both quantitative and qualitative questions that will examine Irish post-primary students' images of mathematics.
3. To gather quantitative and qualitative data through the questionnaire survey and to analyse this data both quantitatively and qualitatively in order to determine the image of mathematics held by 5<sup>th</sup>-year post-primary students; to discover the impact of past experiences of mathematics on students' images of mathematics; to ascertain the factors influencing students' images of mathematics; and to establish the causal attributions for students' success or failure in mathematics.
4. To further analyse the collected data in order to establish the most significant affective, cognitive and/or conative factors in determining students' images of mathematics, to examine the relationship between students' images of mathematics and students' prior achievement in mathematics and to explore any gender differences in students' images of mathematics.

## **Section 1.5: Research Questions**

Each stage of our research study is guided and influenced by the research questions. The initial research question emerging from the research problem is:

- *What is the image of mathematics held by 5<sup>th</sup>-year post-primary students in Ireland?*

The first stage of our research involves a review of the current literature regarding image of mathematics and related issues. Since there is a noticeable lack of published research dealing with image of mathematics specifically, literature on the affective, cognitive and conative aspects of mathematics education was also reviewed, as these three issues are incorporated within our understanding of image of mathematics. The affective, cognitive and conative issues examined in the literature review include attitudes, beliefs, emotions, self-concept and motivation regarding mathematics. This led to the breakdown of the initial research question into a number of sub-questions as follows:

- *Do 5<sup>th</sup>-year post-primary students in Ireland have a positive or negative attitude toward mathematics?*
- *What feelings/emotions do 5<sup>th</sup>-year students in Irish post-primary schools associate with mathematics?*
- *Do 5<sup>th</sup>-year post-primary students in Ireland have confidence in their mathematical ability?*
- *What beliefs do Irish post-primary 5<sup>th</sup>-year students hold about mathematics?*
- *Are 5<sup>th</sup>-year post-primary students in Ireland motivated regarding mathematics?*

These five research questions all contribute to investigating students' images of mathematics and are researched quantitatively through the use of Likert-type scales that are employed in the questionnaire survey. The scales used to examine the five research questions above are outlined in Table 1.1 which shows the name of the scale, the scale's author and the element of image of mathematics examined by the scale.

Scale	Author	Image of Mathematics Element
Enjoyment of Mathematics	Aiken (1974)	Attitude
Value of Mathematics	Aiken (1974)	Attitude
Attitude toward Success in Mathematics	Fennema & Sherman (1976)	Attitude
Effectance Motivation in Mathematics	Fennema & Sherman (1976)	Motivation
Beliefs about Mathematics	Schoenfeld (1989)	Beliefs
Mathematics as a Male Domain	Fennema & Sherman (1976)	Beliefs
Mathematical Self-Concept	Gourgey (1982)	Self-concept
Anxiety about Mathematics	Fennema & Sherman (1976)	Emotions

**Table 1.1: Image of Mathematics Scales**

In addition to the five research questions examined quantitatively through the use of the scales shown in Table 1.1, the literature review also highlighted several issues relating to image of mathematics that were appropriate to our investigation of post-primary students' images of mathematics. This led to the following four research questions:

- *Do their past experiences of mathematics impact 5<sup>th</sup>-year post-primary students' current images of mathematics?*
- *Who influences Irish 5<sup>th</sup>-year post-primary students most in terms of mathematics and the formation of their image of mathematics?*
- *What are the causal attributions of Irish post-primary students in 5<sup>th</sup>-year for success and/or failure in mathematics and do gender differences occur?*
- *Is there a relationship between 5<sup>th</sup>-year post-primary students' images of mathematics and their prior achievement in mathematics?*

The first three of these research questions are examined qualitatively by means of open-ended questions included in the questionnaire survey. The students' responses to the open-ended questions are then analysed both quantitatively and qualitatively and in addition to answering the specific research questions on students' past experiences, influences and causal attributions for mathematical success and/or failure, the students' responses to the open-ended questions also provide a deeper insight into students' images of mathematics, thus informing the initial research question.

## ***Section 1.6: Outline of Thesis***

In this section we present the outline for this thesis, with a summary of each chapter included. The chapters in this thesis are as follows:

***Chapter One – Introduction:*** The PhD study is introduced. The significance and aims of our research study are described. Limitations of our study are stated and the research questions are outlined. A brief introductory description of the theoretical framework and research methodology employed in our study is provided.

***Chapter Two – Literature Review:*** The literature relating to the main research question regarding post-primary students' images of mathematics is reviewed. The main research issue is separated into sub-categories leading to a review of the literature on attitudes, beliefs, emotions, self-concept and motivation regarding mathematics. Research studies on the possible factors influencing students' images of mathematics are also considered in this chapter. These factors include past experiences, mathematics teachers, parents, peers and society.

***Chapter Three – Theoretical Framework:*** "Image of Mathematics" is defined for our study. Drawing on the literature review, the theoretical framework is established. The initial research question and the research questions resulting from the literature review are presented.

***Chapter Four – Methodology:*** The research design for our study is discussed. The methodological stance of our research is set out and the methods to be employed are determined. Details regarding the sampling methodology are provided. The validity and reliability of the study are established and ethical concerns are examined.

***Chapter Five – Pilot Study:*** The findings from the pilot study conducted prior to the main data collection stage are outlined. The pilot study sample details and the preliminary questionnaire are presented. Findings are interpreted and resulting alterations to the questionnaire are made. Implications for the main study are discussed.

***Chapter Six – Quantitative Research Analysis and Findings:*** The completed questionnaires are entered into SPSS for analysis. The quantitative items including both the Student Profile questions and the 8 scales appearing on the questionnaire are analysed. Reliability of the scales for our sample is presented. Scales are analysed individually in line with original analyses conducted by the scales' authors. The 8 scales are also analysed as a combined 'image of mathematics' scale.

***Chapter Seven – Qualitative Research Analysis and Findings:*** The qualitative items from the questionnaire survey are examined both quantitatively on SPSS and qualitatively. The 5 open-ended questions from Section A of the questionnaire are examined thoroughly and qualitatively analysed, bearing in mind the findings from the literature review.

***Chapter Eight – Discussion on and Interpretation of Findings:*** Findings resulting from the quantitative and qualitative analysis are discussed, particularly with a view to addressing the research questions.

***Chapter Nine – Conclusions, Recommendations and Future Research:*** A summary of the thesis and the main findings are presented. Conclusions drawn from the discussion of findings are discussed in terms of their contribution to national and international research. A new model for 'image of mathematics' is outlined.

Recommendations are made based on the findings from our study and future extensions of this research are suggested.

### ***Section 1.7: Description of Terms Used Throughout the Thesis***

In the writing of this thesis, the terms “we” and “our” are used e.g. “we examined” or “our study” and they refer only to the researcher (PhD student Ciara Lane) and not to a group of researchers.

Post-primary education in Ireland is the second stage of education, the first being primary education. Students generally attend primary school for eight years and then attend post-primary school for either five or six years (depending on whether they do transition year – an optional year). Education is compulsory for all children in Ireland between the ages of 6 and 16 or until students have completed three years of post-primary school. As children may begin primary school at the age of 4, 5 or 6, the 5<sup>th</sup>-year students taking part in this study are aged between 15 and 18, and not one set age. Post-primary education in Ireland is also known as second-level education and post-primary schools are often referred to as secondary schools in general (although as described in Chapter Four, secondary schools are only one type of post-primary school). In some of the students’ responses to qualitative questions (analysed in Chapter 7), students may refer to secondary schools but this should be interpreted as referring to post-primary schools in general, not one particular type of post-primary school.

The descriptions Higher, Ordinary and Foundation are used in describing the various levels of mathematics taken by students in our study. Higher level is the highest level of mathematics taken by students in post-primary education in Ireland (also known as Honours). Ordinary level is a lower level of mathematics taken by students (also known as Pass). Foundation level is the lowest level of mathematics that can be taken by students in Ireland. Foundation level is only offered for three subjects on the Irish post-primary curriculum: English, Irish and Mathematics.



The Junior Certificate is a course and examination taken during post-primary education. The Junior Certificate, often called the Junior Cert, is accredited by the State Examinations Commission of Ireland and the examination is usually taken after three years in post-primary school. The Leaving Certificate, also known as the Leaving Cert, is the final course and examination taken by students in post-primary education. The course is a minimum of two years, although there is an optional Transition year following the Junior Certificate examination which means the Leaving Certificate examination often takes place three years after the Junior Certificate examination. The Leaving Certificate examination must be taken by students who wish to attend third-level education (e.g. a university or technical college).

## **Chapter Two**

### **Literature Review**

## **Chapter Two: Literature Review**

In this chapter, we provide an overview of research carried out on images of mathematics, both on an Irish and an international level. We begin with a review of the literature dealing with images of mathematics. Due to the lack of research dealing specifically with this topic, we also examine the elements comprising the concept of ‘image of mathematics’, namely attitudes, beliefs, emotions, self-concept and past experiences regarding mathematics. Finally, we look at the possible factors of influence in forming an image of mathematics. This literature review provides the basis for the theoretical framework of this research study and leads to a number of key research questions to be investigated.

### **2.1 Literature on Image of Mathematics**

Furinghetti (1993, p.34) states that mathematics “*is a discipline that enjoys a peculiar property: it may be loved or hated, understood or misunderstood, but everyone has some mental image of it*”. In this section we look at the definitions of ‘image of mathematics’ found in the literature. Findings from both Irish and international research are discussed in relation to students’, teachers’ and the public’s images of mathematics.

#### **2.1.1 Definition of ‘Image of Mathematics’**

From the literature, it is clear that no universal definition exists for ‘image of mathematics’, with some researchers clearly defining their understanding of the term while others give no explicit definition in their research. Brown (1995) defines ‘image of mathematics’ as “*the personal theory which an individual holds about mathematics at the present time which will include feelings, expectations, experiences*

*and confidences*". Lim (1999) combines the definitions of Thompson (1996) and Rogers (1992) to conceptualize the term 'image of mathematics' as "*a mental representation or view of mathematics, presumably constructed as a result of social experiences, mediated through school, parents, peers or mass media. This term is also understood broadly to include all visual and verbal representations, metaphorical images and associations, beliefs, attitudes, and feelings related to mathematics and mathematics learning experiences*". Kelly & Oldham (1992), in their study of the image of mathematics held by teachers and student teachers in Ireland, refer to views, attitudes and beliefs about mathematics and mathematics education. Similarly, a study by Burton (1989) on top pupils' images of mathematics, although lacking an explicit definition, alludes to students' feelings, attitudes and beliefs. Thus, there appears to be a general consensus in the literature that the term 'image of mathematics' should include attitudes, beliefs, emotions and experiences regarding mathematics.

There is a distinct lack of research dealing with images of mathematics specifically, especially during the last decade. This could, to some degree, be due to the lack of a universal definition for the term. In addition to this, some researchers use various other terms to examine concepts which are very similar to 'image of mathematics'. For example, on an Irish level, Eaton & O'Reilly (2009) examine the *mathematical identity* of student teachers in Ireland. They define mathematical identity as "*the multi-faceted relationship that an individual has with mathematics, including knowledge and experiences, perceptions of oneself and others*". In their study of pre-service teachers in Irish universities, Liston & O'Donoghue (2007, 2009) assess the student teachers' *conceptions* of mathematics and the influence of *affective variables*, including attitudes, beliefs and self-concept regarding mathematics. On an international level, Tait- McCutcheon (2008) discusses students' *self-efficacy* in mathematics, referring to the affective, cognitive and conative domains which include students' self-beliefs, beliefs about mathematics, mathematical knowledge, and intentions and dispositions to learning. Hill (2008) carried out a case study of the *mathematical identity* of five university mathematics students in US. For Hill,

mathematical identity is understood as the interaction of social, personal and ego identities (see Cote & Levine, 2002) which are intrinsically linked with a person's beliefs about mathematics. In particular, Hill examines the motivational beliefs of the students, following the framework of Wigfield & Eccles (2002). Wilson (2011) proposed the construct *disposition* in order to explore the factors engaging life-long learning in mathematical activity. His construct for 'disposition' has many similarities with 'image of mathematics'. 'Disposition according to Wilson has four components namely, beliefs/values/identities, affect/emotion, behavioural intent/motivation, and needs. Similar to 'image of mathematics, the alternative terms used in these recent research studies focus on attitudes, beliefs, self-concept etc. regarding mathematics indicating their continual relevance in current mathematics education research.

### **2.1.2 Students' Images of Mathematics**

In this section we look at literature examining students' images of mathematics as well as research studies using analogous constructs to images of mathematics. Picker & Berry (2000) examined the image of mathematicians held by pupils in lower secondary school level. Students were asked to draw a portrait of a mathematician which was then assessed in order to ascertain the students' beliefs about mathematicians. A common theme found from the portraits was one of "*coercion*". Picker & Berry suggest that this results from the pupils' perception of conformity and authority rather than sense-making in the classroom. This is a signifier of the common problem of rote-learning where the emphasis is on finding the correct answer rather than understanding the method. Boaler (2002a) states that UK and US mathematics is viewed by many students as a collection of disconnected, standard procedures (found by Boaler, 2002b). Hill (2008) in her case-study of five university students deemed to be "*good at math*", found that learning mathematics procedurally was a central belief to two of these students with one stating that "*you have to find the right answer*". Likewise Tait-McCutcheon's (2008) study indicates that students place significance on having the right or wrong answer. Picker & Berry (2000) also found that a number of students appeared to be unaware of the utility of a

mathematician with the majority unable to give even one reason why someone would hire a mathematician. This supports the view held by Hammond (1978, p.17) of mathematics as “*an invisible culture*” and of mathematicians as not a “*rare breed, simply an invisible one*”. Hoyles’ (1982) study on pupils’ views of mathematics learning had similarly negative findings. In her analysis of 14 year old students’ stories about mathematics learning experiences, Hoyles found that 63% related to bad experiences and a much larger proportion of the stories expressed negative feelings about self in mathematics compared with other school subjects (42.7% compared with 24.3%). These findings are consistent with the view that failure in mathematics is commonly associated with feelings of inadequacy, anxiety and shame.

### **2.1.3 Teachers’ Images of Mathematics**

In this section we look at the images of mathematics held by teachers and student teachers as well as related research. Kelly & Oldham (1992) investigated the image of mathematics held by primary school teachers and student teachers in the Republic of Ireland. Their study showed that teachers’ and student teachers’ images of mathematics were largely based on their image of mathematics education, with mathematics seen as process oriented, composed of rules and procedures. These findings are similar to international results from studies by Wilson (1992) and Knudtzon (1996, 1997). Both Wilson and Knudtzon found that teachers’ images of mathematics tend to adhere to a ‘dualistic’ image, where mathematics is viewed as “*a fixed and absolute set of truths and rules laid down by authority*” (Ernest, 1996, p.807). Liston & O’Donoghue (2009) examined pre-service (student) teachers’ conceptions of mathematics with findings indicating a general consensus that procedures are extremely important in mathematics. Rote-learning and a reliance on rules and formulae were common among the student teachers interviewed in the study by Liston & O’Donoghue which, the authors caution, could be replicated in these student teachers’ future teaching style. As noted by Philippou & Christou (1998), the experience which people have of mathematics at school is not always positive, and quite often they leave school with a negative image of mathematics. For those who become mathematics teachers, this can cause a vicious circle as the teacher passes

this negative image on to his or her students. Meehan & Paolucci (2009) looked at student teachers' conceptions of mathematics and teaching mathematics in five Irish universities. The following four categories were found by Meehan & Paolucci as a result of student teachers' explanations for why mathematics differs to other school subjects:

- 1) Mathematics is a “doing”/”practical” subject (40 respondents).
- 2) One must understand mathematics (20 respondents).
- 3) Mathematics is either right or wrong (20 respondents).
- 4) Mathematics has a method/process to it (31 respondents).

These categories tie in with the findings by Liston & O'Donoghue (2009), Kelly & Oldham (1992), Wilson (1992) and Knudtzon (1996, 1997) with many teachers and prospective teachers both in Ireland and abroad adhering to the dualistic image of mathematics.

#### **2.1.4 Public Image of Mathematics**

This section compares the image of mathematics held by mathematicians with the image held by the general public. *“Probably no area of human activity is as afflicted as mathematics with a gap between the public perception of its nature and what its practitioners believe it to be”* (Barbeau, 1990, cited in Picker & Berry, 2000). A review of the literature quickly illustrates that the public image of mathematics differs greatly from what mathematicians believe it to be (Picker & Berry, 2000). The image of mathematics held by mathematicians as found by Burton (1997) is that of a collaborative process, resulting in a *“rich sense of pleasure”* when success is achieved. This is consistent with findings by Grigutsch & Torner (1998) in which 90% of university mathematics teachers asked, viewed mathematics as a process. The image held by mathematicians is in stark contrast to the image of mathematics held by the majority of the general public. Ernest (2004) states that *“a widespread public image of mathematics is that it is difficult, cold, abstract, theoretical, ultra-rational, but important and largely masculine”*. He suggests that mathematics has an image of *“being remote and inaccessible to all but a few super-*

*intelligent beings with ‘mathematical minds’*”. In 1999, Lim investigated the public image of mathematics in the UK and her resulting images of mathematics are classified into five categories as follows:

- The absolutist or dualistic image,
- The utilitarian image,
- The symbolic image,
- The problem-solving image,
- The enigmatic image.

These images of mathematics outlined by Lim can be seen in much of the literature on images of mathematics (and the related concepts mentioned in Section 2.1.1) although not always under these specific titles used by Lim. To elaborate on the prevalence of these images of mathematics we look at each separately.

The first, the *absolutist/dualistic* image, is the image of mathematics as a set of “absolute truths”, with only one right answer. The style of teaching that many students experience in school, which focuses on the product of mathematics rather than its processes, has been discussed and criticized by many researchers in the field (see Schoenfeld, 1987; Furinghetti, 1993; Henrion, 1997). Evidence of the absolutist or dualistic image of mathematics can be seen in Wilson, 1992; Knudtzon, 1996, 1997; Hill, 2008; Tait-McCutcheon, 2008; Eaton & O’Reilly, 2009; Meehan & Paolucci, 2009. In some cases, this may produce a positive image of mathematics, as it is more precise than other disciplines of study. There is a solution to each mathematical problem and if you find it then nobody can say you are wrong. On the other hand, of course, this can also produce a negative image, that of a subject lacking creativity and it can be frustrating when you cannot reach the one true solution. The Perry Scheme of dualistic versus relativist belief system has been applied to mathematics by such researchers as Copes (1982) and Ernest (1996). They suggest that people either have a dualistic/absolutist image of mathematics, i.e., that mathematics is either right or wrong; certain and exact; and value-free and culture-free, or people will hold a relativist image of mathematics, i.e., that it is a dynamic,



problem-driven and continually expanding field of human creation (Ernest, 1996, p.808).

The *utilitarian* image views mathematics in terms of its usage and relevance. Usually, for those who like mathematics and have a positive image, mathematics is seen as a useful tool, while for those who dislike mathematics and have a negative image, mathematics is seen as irrelevant and not to be applied to everyday life. As seen in Section 2.1.2, Picker and Berry (2000) in their research on students' images of mathematicians found a distinct lack of awareness of the utility of mathematicians. There appeared to be a common agreement that *"no one is so stupid as to hire a mathematician"* (Picker & Berry, 2000, p.71). In Hill's (2008) case-study of five mathematics university students, she found varied responses on the usefulness of mathematics. In particular, while one student *"believed that we use mathematics in nearly everything, although it is often used subconsciously"*, another student was found to have a very negative image of mathematics in terms of usefulness claiming *"can't think of anything now that would strike the average person as amazing or extraordinary, something that came from the mathematics field"* with a third student struggling to find examples of mathematics use in everyday life. If these mathematics students fail to see the usefulness of mathematics, it does not bode well for public opinion.

The *symbolic* image of mathematics is that it is a collection of numbers and symbols, or rules and procedures to be followed and memorized. This image has similarities with the dualistic image aforementioned, with the two categories of image often going hand in hand. The pervasiveness of the symbolic image of mathematics can be seen from the findings of Boaler, 2002a; Eaton & O'Reilly, 2009; Meehan & Paolucci, 2009; Liston & O'Donoghue, 2009. Rote learning in our schools has led to this common image of mathematics. De Corte et al (1996) and Wang & Lin (2005) support this, stating that in many of our schools, the impression that students receive of mathematics is an emphasis on routine, inflexible, abstract knowledge as the current education system fails to support the development of the students' conceptual, problem-solving and flexible mathematical knowledge.

The *problem-solving* image sees mathematics as a set of problems to be solved. While not as common as the three former categories of image, this image can be seen in Hill (2008). The problem-solving image of mathematics ties in with the relativist image aforementioned. Problem-solving can also be found in the form of recreational puzzles, cryptic crosswords, riddles, etc. In particular, the popularity of “sudoku” in recent years illustrates that the general public enjoy solving mathematical problems, and finding their solution.

Finally, the *enigmatic* image of mathematics is of something seen as mysterious but yet something to be explored and whose beauty is to be appreciated. Lim (1999) found that a small minority of the sample, particularly those who liked mathematics and were directly involved with mathematics, viewed the subject as an enigma, something foreign and at times incomprehensible but elegant at the same time. It can be seen as something to explore, and the image of mathematics as a journey was a recurring metaphor in her findings. A related perception is the image of mathematicians as a wizard or as a “mathemagician”, a word which has been heard more frequently in recent times. Because people do not always understand the mathematical process, mathematics looks more like a magical power than an ability that anyone can learn (Picker & Berry, 2000, p.84). The notion of mathematics as a magical power also ties in with the view that the solution is most important, not the method which has become mere rote learning rather than being understood which in turn creates the image of mathematics as an unattainable skill, and impossible for those who do not possess a natural mathematical ability.

These five images are not strictly separate, and a person’s image of mathematics may fall into one, several or even none of this categories. The images of mathematics categorized by Lim (1999) do however provide a guideline for assessing the images of mathematics found in the literature. From the research studies on students’ and teachers’ images of mathematics, it is clear that the majority of students’ and teachers’ mathematical images adhere to the absolutist or dualistic image, often coinciding with the symbolic image of mathematics, with less evidence of the other categories to be found.

In order to obtain a more complete understanding of ‘image of mathematics’, we also need to examine the elements constituting the concept of ‘image of mathematics’ as found in the literature, namely attitudes towards mathematics, beliefs about mathematics, self-concept in mathematics, emotions about mathematics and the past experiences regarding mathematics.

## **2.2 Literature on Attitudes towards Mathematics**

Unlike image of mathematics, there has been extensive research on attitudes towards mathematics and a thorough review of this literature is beyond the scope of this thesis. We focus on the most prominent areas of inquiry in mathematical attitude research; in particular gender differences in attitudes and the relationship between attitude and achievement in mathematics are discussed.

### **2.2.1 Attitude Definitions**

Similar to the literature on ‘image of mathematics’, researchers follow various definitions for attitudes to mathematics. Ajzen (1988, p.3) defines attitude as the disposition to react positively or negatively to an object, person, institution or event, or in this case mathematics. This is similar to Aiken (1970) who referred to attitude as *“a learned predisposition or tendency on the part of an individual to respond positively or negatively to some object, situation, concept, or another person”*. Neale (1969) defined attitude to mathematics as *“an aggregated measure of a liking or disliking of mathematics, a tendency to engage in or avoid mathematical activities, a belief that one is good or bad at mathematics, and a belief that mathematics is useful or useless”*. Hemmings et al. (2010) adopt the view that mathematical attitudes are a positive or negative response towards mathematics and that this response is relatively stable. Ma & Kishor (1997) and Liston (2009) adopt Neale’s definition for their study, while Haladyna et al. (1983) use a similar definition to Ajzen and Aiken above with attitude toward mathematics seen as a general emotional disposition toward the subject of school mathematics. Lim (1999) follows the definition asserted by McLeod (1992) as *“affective responses that involve positive or negative feelings of moderate*

*intensity and reasonable stability*”. These are just some of the most common definitions used in research dealing with attitudes towards mathematics, with many studies lacking an explicit definition of their understanding of attitude.

Despite the various definitions of attitude to be found in the literature, there seems to be three basic features about the concept of ‘attitude’ that:

- Actions are consistently favourable or unfavourable toward the object,
- Attitudes are predispositions,
- Attitudes are learned. (Fishbein & Ajzen, 1975).

According to Fishbein & Ajzen (1975, p.10), attitudes are “*predispositions to respond in consistently favourable or unfavourable ways*” and this predisposition is not innate but “*assumed to be the result of past experience*”.

Some of the definitions used by researchers are also based on attitude dimensions, the factors which make up the general term ‘attitude’. Attitude dimensions are outlined in the next section – Section 2.2.2.

## **2.2.2 Attitude Dimensions**

Research on attitude to mathematics and mathematics learning came to the fore during the 1970s. In this decade, new attitude scales were developed, including Aiken’s Two Scales of Attitude Toward Mathematics (1974) and the Fennema-Sherman Mathematics Attitude Scales (1976). Prior to this, instruments to measure attitude to mathematics focused on only one dimension, but now researchers became interested in testing various aspects of attitude (see Table 2.1). Even today, these scales remain a reliable and popular measure for mathematical attitudes and have also formed the basis for the creation of other attitude scales (for example Sandman’s Mathematics Attitude Inventory (1980) is based on Aiken’s scales of 1974). In particular, the Fennema-Sherman scales (1976) have had a substantial impact on the field of attitude research according to McLeod (1994) especially (but not exclusively) in the area of gender differences in mathematics.

<b>Attitude Scales</b>	<b>Attitude Dimensions</b>
<b>Aiken (1974): Two Scales of Attitude Toward Mathematics</b>	<ul style="list-style-type: none"> <li>• Enjoyment of Mathematics Scale</li> <li>• Value of Mathematics Scale</li> </ul>
<b>Fennema &amp; Sherman (1976): Mathematics Attitude Scales</b>	<ul style="list-style-type: none"> <li>• Mother Scale</li> <li>• Father Scale</li> <li>• Teacher Scale</li> <li>• Confidence in Learning Mathematics Scale</li> <li>• Mathematics Anxiety scale</li> <li>• Effectance Motivation scale</li> <li>• Mathematics Usefulness Scale</li> <li>• Mathematics as a Male Domain scale</li> <li>• Attitude Toward Success in Mathematics Scale</li> </ul>

**Table 2.1: Attitude Dimensions**

### **2.2.3 Attitude and Achievement in Mathematics**

Attitude towards mathematics has been extensively researched in relation to achievement in mathematics. There is some division between researchers on whether attitudes influence achievement or achievement influences attitude, with other researchers arguing that there is a reciprocal relationship between the two. The relationship between attitude and achievement appears to vary in significance depending on year of schooling. Aiken (1970) suggested that the strongest relationship between the two is found where variability of achievement is greatest. As such, the lowest correlation between attitude and achievement in mathematics tends to be found at elementary or primary school level where differences in achievement are less significant, with the highest correlation found at post-primary level where students are likely to be grouped by ability/prior achievement and therefore differences in mathematical achievement are more noticeable.

With regard to attitudes to mathematics influencing achievement in mathematics, this view is supported by Hemmings et al. (2010), Jackson (1968) and Enemark & Wise (1981). Ma & Kishor (1997) examined the relationship between attitude and achievement in a meta-analysis of 113 studies and discovered that the relationship was positive and reliable but not strong. In addition, Jackson (1968) maintained that it is only at the attitude extremes – highly positive or highly negative – where attitude affects achievement in mathematics. Indeed the majority of researchers agree that while attitude has an effect on achievement in mathematics, it is only one of many variables that determine mathematics achievement. These other variables include prior achievement in mathematics and ability. In relation to achievement influencing attitudes to mathematics, Ma & Kishor (1997) found the relationship to be insignificant. However, Brassell et al. (1980) found that the lower-end pupils in a medium-level ability mathematics class had the lowest scores for enjoyment of mathematics suggesting that lower achievement in mathematics can negatively influence students' attitudes to mathematics. Oldham (2005) noted that 'less mathematical' students' self-confidence was found to be undermined when in the same grouping as more able peers. The influence of prior achievement on attitude to mathematics is also seen in the longitudinal study by Stevenson & Newman (1986).

The literature indicates that the relationship between attitude and achievement in mathematics varies according to the attitude dimension assessed. For example, Reynolds & Walberg (1992) found that motivation influences and is influenced by achievement in mathematics. On the other hand, they found that perceived usefulness of mathematics had a relatively low correlation with mathematics achievement. Liston (2009) found that enjoyment of mathematics and self-concept in mathematics influence performance in mathematics. Brassell et al. (1980) concluded that self-concept and anxiety in mathematics were the most important correlates of mathematical achievement rather than motivation or enjoyment of mathematics. Cheung (1988) had similar findings with students' estimation of their own abilities in mathematics found to have the greatest influence on their mathematics achievement.

Hannula et al. (2004) found a relationship between self-confidence and achievement in mathematics which was affected by gender.

The disparity among researchers in relation to the attitude-achievement relationship is clearly exacerbated by the inconsistency in the literature as to which attitude measures are used to assess the relationship. Also the lack of a universal definition for attitude means that the understanding of attitude varies among researchers with consequently a range of attitude dimensions appearing under the heading of 'attitude' in the research studies. These inconsistencies must be accounted for in analysing the attitude-achievement relationship, as for many research studies, the dimensions of self-concept and mathematical anxiety are the most influential factors, and some would argue that they do not fall strictly under the attitude sector.

#### **2.2.4 Gender and Attitude towards Mathematics**

Research on attitudes towards mathematics has mainly investigated students' attitudes to mathematics as a school subject, and many of these studies have also examined gender differences with regards to these attitudes. It is clear from the literature that the effect of gender on mathematics performance has diminished in recent years (Hyde et al., 1990; Eivers et al., 2009), yet according to Kaiser-Messmer (1993), females tend to have a more negative attitude toward the subject of mathematics.

Kaiser-Messmer's empirical study carried out in Germany on gender differences in attitudes to mathematics, highlights a varying degree of difference between the sexes depending on school level. At lower secondary school level, her study shows that significantly fewer girls than boys express an interest in mathematics, with twice as many girls as boys expressing no interest in mathematics. These gender differences become less pronounced at upper secondary school level, particularly in advanced level courses. It is important to note that although a greater number of girls expressed interest in mathematics at upper secondary level, a large number still opt to study mathematics at a basic level which Kaiser-Messmer attributes to a lack of self-confidence in their mathematical ability. The link between

low self-confidence in ability in mathematics and negative attitudes to mathematics is also illustrated by Relich (1996). He found that mathematics teachers with low self-concept, that is, low confidence in their own ability in mathematics, tend to have negative attitudes towards mathematics, while those with a high self-concept expressed more positive attitudes.

The impact of school type and the sex of the teacher on students' attitudes towards mathematics has been the subject of some debate among researchers. Badger (1981) suggested that females attending co-educational schools have more positive attitudes to mathematics than females attending single-sex schools. This contrasts with the findings of Lee & Lockheed (1990) in which females attending single-sex schools showed more positive attitudes. Mallam (1993) had similar results with the highest proportion of females with positive attitudes to mathematics found in single-sex secondary schools where mathematics was taught by female teachers. She also notes that the lowest proportion attended co-educational secondary schools where mathematics was taught by male teachers. Mallam attributes these attitudinal differences to the fact that females attending single-sex schools do not have to compete with males for attention. This is only one possible explanation. It is feasible that girls taught by female teachers have more positive attitudes because their teacher acts as a female role-model in a male-dominated industry.

Perhaps the most viable explanation for gender differences in the research literature on attitudes to mathematics can be found in relation to attributions of success and failure in mathematics by males and females. Weiner (1974) proposed a model of causal attribution in the shape of a 2x2 matrix with the dimensions of locus of causation (internal-external) and stability (stable-unstable). The resulting four categories of attributions are as follows:

- Ability (internal and stable)
- Effort (internal and unstable)
- Task difficulty (external and stable)
- Luck (external and unstable).



Fennema (1977) and Pedro et al. (1981) maintained that, in general, males more than females attribute success to ability (a stable factor), while females more than males attribute success to effort (an unstable factor). Similarly, males tend to attribute failure to an unstable factor such as effort, while females tend to attribute failure to a stable factor such as ability. Fennema (1977) found that these sex-related differences are generally larger if the task at hand is sex-typed as masculine, as in mathematics.

In their study on the election of high school mathematics by females and males, Pedro et al. (1981) examined the attitudes, attributions of success/failure and mathematics achievement of students. Their findings suggest that gender differences in relation to attitudes are not as significant as differences in attributions of success and failure. For example, perceived usefulness of mathematics was found to have the strongest influence on the mathematics plans of both males and females. The greatest difference between the genders was found in relation to anxiety and their attributions of success and failure. In the study by Pedro et al., a male student with low anxiety appeared to attribute success in mathematics to ability which is supported by the fact that the Anxiety scale and the Success-Ability scale correlated to the same degree with mathematical plans for males in the study. For females however, the Failure-Ability scale correlated highly with the Anxiety scale for females which supports the consistent findings in the attitude literature that females are more anxious about mathematics than males and thus are more likely to attribute failure to ability. A recent study by Tait-McCutcheon (2008) which investigated the self-efficacy of students (aged 8-11) found that the majority of students sampled attributed success in mathematics to controllable factors such as hard work, that is the same as the internal factor of effort in Weiner's 1974 model.

Gender differences in attitudes to mathematics played a major role in mathematics education research in the last century, particularly after the development of the Fennema-Sherman Mathematics Attitude Scales (1976) and therefore it was necessary to acknowledge this previous research in our literature review. In the last decade or so, there has been a significant shift in the area of gender differences, focusing now on self-confidence, self-efficacy beliefs and self-concept in

mathematics. While these terms have been used by some researchers under the heading of ‘attitude’, they will be discussed separately in this chapter in Section 2.4.

## **2.3 Literature on Beliefs about Mathematics**

Research examining beliefs about mathematics will be discussed in this section. Definitions of belief will be outlined as well as the relationship between beliefs and knowledge. We then examine a number of stereotypical beliefs about mathematics that have become prevalent in society, among students and teachers in particular.

### **2.3.1 Definitions of Beliefs**

Beliefs and knowledge are intrinsically linked in the literature so it is necessary to distinguish between the two before examining the research. For some researchers, beliefs are thought to form part of an individual’s metacognition, and therefore they are seen as an element of knowledge (Furinghetti, 1996; Schoenfeld, 1987). Other researchers disagree and view beliefs as distinct from knowledge and within the affect spectrum along with attitudes (McLeod, 1994; Grigutsch, 1998; Liston, 2009). Hannula (2004) identifies some kind of truth value as a characterisation that distinguishes beliefs from attitudes and emotions. Furinghetti & Pehkonen (2002) attempt to clarify these definition problems, differentiating the two as:

- *Knowledge*: objective (formal, public) knowledge
- *Beliefs*: subjective (informal, personal) knowledge.

Similarly, Op’t Eynde, De Corte & Verschaffel (2002) state that beliefs are individual constructs while knowledge is essentially socially constructed with Hannula (2006) adding that individual beliefs are falsifiable, as new experiences may challenge old beliefs and lead to a change in beliefs. In general, researchers agree that beliefs differ from knowledge on the grounds outlined by Furinghetti & Pehkonen (2002). The level to which they relate to attitudes and emotions, however, still remains undecided although the majority of the literature on beliefs research agrees that beliefs interact

to some degree with the affective issues of attitude and emotion, for example, Fishbein & Ajzen (1975) conceptualize beliefs about an object (in this case mathematics) as providing the basis for the formation of an attitude toward the object (mathematics).

### **2.3.2 Beliefs about Mathematics**

Schoenfeld (1989) suggests that students' problem-solving/mathematics performance is often undermined by their beliefs about mathematics. In particular, beliefs such as "mathematics is simply memorizing rules" and "there is only one correct way to solve a problem" have been instrumental in creating a negative image of mathematics in our schools. In addition to these beliefs, there are a number of stereotypes or myths about mathematics that have become accepted as 'truths' in society. Cultural myths offer a set of ideal images, definitions and justifications that are taken as measures for thought, effect and practice (Britzman, 1991, p.6).

Kogelman & Warren (1978) asserted that there exist 12 mathematical myths which produce a negative image of mathematics in society. They are:

- 1) Some people have a mathematical mind and some don't.
- 2) Mathematics requires logic, not intuition.
- 3) You must always know how you got the answer.
- 4) There is a best way to do a mathematical problem.
- 5) Mathematics requires a good memory.
- 6) Mathematics is done by working intensely until the problem is solved.
- 7) Men are better in mathematics than women.
- 8) It is always important to get the answer exactly right.
- 9) Mathematicians do problems quickly in their heads.
- 10) Mathematics is not creative.
- 11) It is bad to count on your fingers.
- 12) There is a magic key to doing mathematics.

In addition, Paulos (1992) identified five myths which he titled “*mathematics-moron myths*” (p.335):

1. Mathematics is computation.
2. Mathematics is a rigidly hierarchical subject.
3. Mathematics and narrative are disparate activities.
4. Mathematics is only for the few.
5. Mathematics is numbing.

These overlap with the myths outlined by Kogelman and Warren above. Frank (1990) in his study on mathematical myths held by teachers used the twelve myths suggested by Kogelman and Warren (1978) as a survey questionnaire to 131 pre-service elementary teachers enrolled in a mathematics class. The results were shocking but illustrated that these myths are indeed popular beliefs. Frank found that at least half of the teachers agreed with the first three myths, that is (1) Some people have a mathematical mind and some don't – 63%, (2) Mathematics requires logic, not intuition – 53% and (3) You must always know how you got the answer – 50%. All the twelve statements were chosen by at least ten of the teachers.

Mathematical myths are perhaps one of the strongest influences on the public image of mathematics. These myths are also described as memes (see Dawkins, 1989; Rothstein, 1998; Aunger, 1999) which is a small amount of cultural information, a ‘catch phrase’ that is passed from person to person by imitation. The major influence upon people is people, and even in our technologically advanced society, there is no substitute for direct human contact (Bem, 1970, p.75). Myths or memes have been spoken of for many years and have become permanent images of mathematics held by many students, teachers, parents, and members of the public in general. These myths are detrimental to the public image of mathematics, and because they have been built into society for so long, they are nearly impossible to dispose of.

From the literature, two of the stereotypical beliefs about mathematics which have received significant attention from researchers are (1) Some people have a

mathematical mind and some don't, and (2) men are better at mathematics than women.

### 2.3.3 The Mathematical Mind

Performing well in mathematics is often mistakenly viewed as an indication of high intelligence (Kogelman & Warren, 1978, p.22). As mentioned in Section 2.1.4, the public image of mathematics found by Ernest (1996) was that it is *“inaccessible to all but a few super-intelligent beings with ‘mathematical minds’”*. This concurs with Burton (1995, p.276) who acknowledges that mathematics is perceived by many students and teachers as a body of established knowledge accessible only to a few extraordinary individuals. This is supported in a study by Wood & Smith (1993, p.596) in which they found that some students felt that *“self-discovery in mathematics was only for the very smart”*. Mathematics has a reputation as being one of the most difficult subjects in school, and therefore the assumption is made that students who do well in mathematics are more intelligent than those who do badly. Due to the belief that mathematics is accessible to only *“super-intelligent beings with mathematical minds”*, it has become acceptable to a certain degree to ‘not be good at mathematics’. Furthermore, Maqsdud & Khalique (1991, p.377) suggest that ignorance of the subject is often a point of pride.

The existence of the so-called mathematical mind is a myth which many people believe to be a fact (Kogelman & Warren, 1978, p.42). In the 2003 PISA study and the 1995 TIMMS study, teachers were asked whether they agreed with the statement *“Some students have a natural talent for mathematics and others do not”*. From the PISA study, 92.4% of teachers agreed or strongly agreed with this statement, while in the TIMMS study, 90% of students who took part were being taught by teachers who agreed with this statement (Breen et al., 2007). Lyons et al. (2003) found that ten post-primary teachers in Ireland all agreed with this statement also. Tait-McCutcheon's (2008) study on students' self-efficacy in mathematics found that although many students disregard the notion of innate ability, 72% agreed that some people just cannot do mathematics. On the other hand, Breen et al. note

that the majority of students did not view innate ability as important as teachers did. A total of 82% of students agreed that it is possible to improve on mathematical ability with 58% agreeing that practice and hard work can help ability. Schoenfeld (1989) had similar findings that the majority of students placed more emphasis on work than inherent talent, with many of the sampled students believing mathematics to be an objective discipline which can be mastered. Carmichael & Taylor's (2005) study of adult learners found that, similar to the students beliefs in Schoenfeld and Breen et al., adult learners subscribe to an incremental view of intelligence (that intelligence is malleable and can be improved) rather than an entity view (that intelligence is a static entity or fixed trait). This supports Hope's (1985) study on expert mental calculation in which he proposes that the most important requirement for acquiring any expertise is interest. He also found that in contrast to the myth that mathematics requires a higher intelligence, expertise in mental calculation requires the same degree of constant practice, undivided attention, and knowledge as expertise in any other field of human endeavour. Similarly, Butterworth (2006, p.565) concluded that zeal and a disposition for hard work rather than innate ability are the tools for success in mathematics.

One theory that counters the belief about the existence of the 'mathematical mind' is that of Habermas (1972). His theory of knowledge and human interest differentiates three generic cognitive areas in which human interest generates knowledge (see Table 2.2). As part of this theory, Habermas identifies *technical interest* as one of the three fundamental knowledge-constitutive interests that everyone possesses. This technical interest is what encourages us to achieve control over nature and ties in with the analytic sciences according to Norwich (2000, p.49). Mathematics is, in its very essence, analytical and therefore it follows that each of us inherently has some degree of interest in learning mathematics.

<b>Type of Human Interest</b>	<b>Kind of Knowledge</b>	<b>Research Methods</b>
Technical (prediction)	Instrumental (causal explanation)	Positivistic Sciences (empirical –analytic methods)
Practical (interpretation and understanding)	Practical (understanding)	Interpretive Research (hermeneutic methods)
Emancipatory (criticism and liberation)	Emancipation (reflection)	Critical Social Sciences (critical theory methods)

**Table 2.2: Habermas' (1972) Three Domains of Knowledge**

These research studies indicate that the belief about the existence of the mathematical mind is most prevalent among teachers. This is of particular concern as according to Dweck, 1986 and Lyons et al., 2003, teachers' views of students' ability can actually affect some students' performance, leading to a “*self-fulfilling prophecy*” (Breen et al., 2007).

#### **2.3.4 Gender and Mathematical Beliefs**

Numerous studies have been carried out on gender and mathematics, particularly during the 1970s and 1980s, and no significant evidence has emerged to suggest that men are genetically better at mathematics than women (see Kogelman & Warren, 1978; Leder, 1980 & 1985; Maines, 1985; Fennema, & Peterson, 1985; Fennema, 1979; Mendick et al., 2008). Indeed the Second International Mathematics Study reported that differences in mathematical performance between countries are greater than differences between genders (Hanna, 1989). In addition, Pehkonen (1997) carried out an international study on students' beliefs and found that

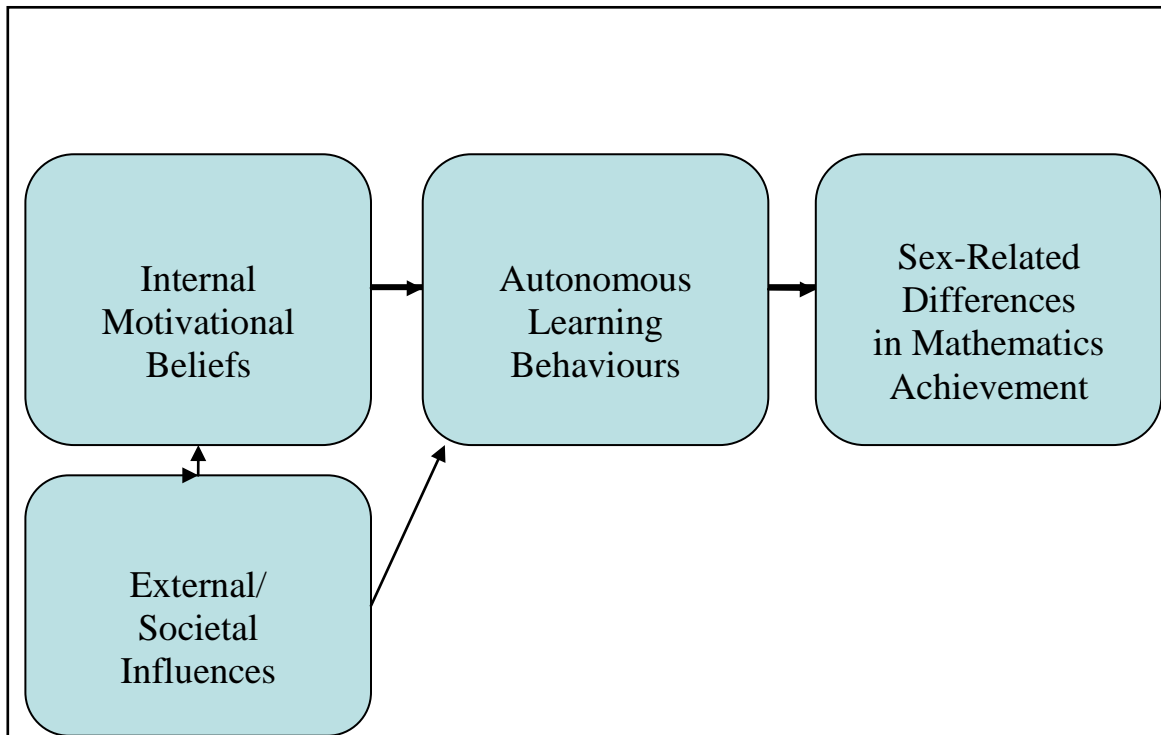
differences between countries were more frequent than differences between genders regarding mathematical beliefs.

Nevertheless, it is clear that the image of mathematics and of mathematicians in the twenty-first century is still one of a male-dominated domain (see Picker & Berry, 2000; Lim & Ernest, 1999, Mendick et al., 2008). There is no denying that, in general, the majority of students studying mathematics and mathematics-related subjects at third-level are male and that more boys than girls perform well in mathematics (Leder, 1980, p.411). Perkins et al. (2007) noted that in the PISA study, male students significantly outperformed females on the combined mathematics scale in 21 of the 29 OECD countries, including Ireland. Males in Ireland scored higher than females on all four of the mathematics content scales. Soro (2000, 2002) suggests that girls are seen to employ inferior cognitive skills and succeed because of their diligence, while boys are seen to be talented in mathematics but lacking in effort. This ties in with Weiner's 1974 theory mentioned in Section 2.2.4. From the literature, however, the reason for gender differences in mathematical performance is more likely to be societal pressure, cultural stereotypes and self-efficacy beliefs than biological constraints (Leder, 1985, p.305).

In his study of mathematically talented students, Kissane (1986) noted significant gender differences in favour of boys in the SAT-M scores. He suggests that, particularly in the case of the Year Eleven students (the eldest group tested), the most feasible hypothesis is that socialization effects and peer pressures on girls have reduced the likelihood of higher-scoring girls continuing with advanced mathematics. Kissane's hypothesis ties in with the research by Fennema & Peterson (1985) in which they assert that the traditionally perceived female sex-role identity is not one which incorporates mathematical achievement. They suggest that, although there is no longer a strict division between the role of females and males, latent beliefs about identity can cause females to be less motivated in mathematics which in turn hinders their development of autonomous learning behaviours (ALB – see Figure 2.1). In a later study, Fennema et al. (1990) found that teachers believed that boys showed more



characteristics of autonomous learning behaviour than girls and they also perceived boys to be their best students.



**Figure 2.1: Autonomous Learning Behaviours**

strong belief held by people in general that mathematics is an intense and difficult subject, which requires more time and effort than other less regulated subjects. Maines (1985) proposes the theory that women live in diffuse worlds rather than focused worlds, whereby they focus their energy on a broad spectrum of activities rather than dedicating their attention to one primary activity. They tend to feel an increased moral responsibility to family, friends and social aspects of life compared with men. As such they are less likely to follow and/or succeed in a mathematics career as, owing to the nature of the subject, they believe it requires dedication to this subject alone, neglecting other aspects of their life (Eccles, 1985, p.313). This could be an explanation for the number of females studying such courses as nursing and the humanities, with fewer women choosing to study physics, engineering and mathematical sciences. Regardless, as long as mathematics continues to be stereotyped as a male-oriented subject, girls may continue to shun it when possible.

Even girls who possess a strong mathematical ability may be deterred from specializing in mathematics unless the image of mathematics is altered, and female role-models emerge (Head, 1981, p.346). On a positive note, the situation regarding gender differences in mathematics began to transform from the 1990s onwards with Palsdottir (2007) noting that some research showed that beliefs towards mathematics, the study of mathematics, and the experience of being a learner of mathematics, which were held by pupils in lower secondary schools, were changing.

It is evident from the literature on beliefs that gender differences in mathematics are insignificant with regards to biological factors. It should be noted that societal changes, particularly in the area of women and mathematics, may have played an influential role in the newer studies which refute earlier beliefs about the supremacy of males in mathematics. With sex differences in mathematics diminishing, and women no longer viewed as intellectually inferior in mathematics, this also has implications for the notion of the ‘mathematical mind’ (Section 2.3.3), which would have been previously seen as something possessed predominantly by males.

The most likely explanation for gender differences in mathematics lies in the area of self-beliefs, that is, beliefs about one’s own ability in mathematics. These self-beliefs together with one’s self-confidence and anxiety levels in mathematics have emerged in recent times as the major concern in literature on gender and mathematics. These will be discussed in the following two sections.

## **2.4 Literature on Self-Concept in Mathematics**

The emergence of self-concept in mathematics education research is a relatively newer phenomenon than are attitudes and beliefs about mathematics. Self-concept in mathematics is often used inter-changeably with self-belief, self-confidence and self-efficacy beliefs regarding mathematics. These terms will be outlined in this section, followed by a review of the literature dealing with self-concept in mathematics.

### **2.4.1 Definitions of Self-Concept**

Gourgey (1982) defines mathematical self-concept as *“beliefs, feelings or attitudes regarding one’s ability to understand or perform in situations involving mathematics”*. Drew & Watkins (1998) define self-concept as *“a psychological construct which refers to the cluster of ideas and attitudes an individual holds about himself”*, while Reyes (1984) states that mathematical self-concept is a perception of personal ability to learn and perform tasks in mathematics. These definitions of self-concept have similarities with the definitions of self-confidence and self-efficacy in mathematics. For example, Broekmann (1998) defined ‘confidence’ as *“the knowledge or belief that one can learn to do”*, while Fennema & Sherman (1976) refer to their Confidence in Learning Mathematics Scale as a measure of confidence in one’s ability to learn and to perform well on mathematical tasks. Hill (2008) acknowledges confidence as *“a belief in one’s ability to perform a specific task”* and draws a comparison between confidence and self-efficacy which she defines as *“an individual’s personal belief in his or her own ability to achieve a goal”*. Similarly, Bandura (1997) identifies self-efficacy as an individual’s belief in their own capacity to be successful. Tait-McCutcheon (2008) defines self-efficacy as *“the judgements we make about our potential to learn successfully and the belief in our own capabilities”*. One of the most complete theories of self-efficacy in mathematics is found in Tait-McCutcheon’s study. Based on the theory of Tanner & Jones (2000, 2003) and Bandura (1977), Tait-McCutcheon suggests that self-efficacy is comprised of three ‘domains of functioning’, affective, cognitive and conative. The affective domain includes beliefs about the self and one’s capacity to learn mathematics; self-

esteem and one's perceived status as a learner; beliefs about the nature of mathematical understanding; and one's potential to succeed in mathematics. The cognitive domain is concerned with one's awareness of his/her mathematical knowledge. The conative domain refers to the act of striving, of focusing attention and energy and purposeful actions. It includes a person's disposition to learn, their approach to monitoring their own learning and self-assessment. Each of the constructs self-concept, self-confidence and self-efficacy hold a common emphasis of 'belief in one's own ability', and therefore research studies will be included in this section based on this understanding.

### **2.4.2 Self-concept in Mathematics**

Self-concept plays a major role in mathematics. This is evident from Hoyle's (1982) study in whose findings show that students' mathematical experiences were dominated by a focus on the self and feelings about oneself. Findings from Meehan & Paolucci (2009) identify students' low mathematical self-efficacy as a reason why mathematics is difficult to teach. Sax (1992) found mathematical confidence decreased over time and was most strongly predicted by second-level (i.e. post-primary school) experience.

According to Bandura (1992), efficacy beliefs play a central role in the effort made in the pursuit of one's personal goals, in persistence when faced with adversity, and the ability to rebound from temporary setbacks. Self-concept and confidence levels have been shown to influence clearly how well people perform tasks. Fennema & Sherman (1978) discovered that self-confidence in mathematical ability was highly correlated with achievement in mathematics, more so than any other affective variable. In Liston (2009) self-concept was seen to influence performance in mathematics (see Section 2.2.3), with similar findings in Brassell et al. (1980) and Cheung (1988). Hannula et al. (2004) indicate that the relationship between self-confidence and achievement in mathematics is affected by gender. Fennema and Sherman (1977, 1978) found that boys consistently showed greater self-confidence than girls in their ability to learn mathematics (see also Forgasz, 1995; Tartre &

Fennema, 1995). Fennema & Peterson (1985) also placed a student's internal belief system about mathematics and his/herself as the central motivator to participation in their autonomous learning behaviours (ALB) model (see Section 2.3.4) which they propose as one of the chief differences between males and females in mathematics. Hannula et al. (2002) found lower self-confidence among female students even on individual tasks such as in the case of correct or incorrect answers. The role of self-concept in gender differences and achievement in mathematics is also seen in females and males causal attributions for success and failure in mathematics as mentioned in Section 2.2.4.

Self-confidence and self-concept in mathematics are closely related to anxiety in mathematics. Indeed Fennema & Sherman (1976), using their Mathematics Attitude Scales, found that a high score on the Confidence in Learning Mathematics Scale correlated highly with a low score on the Mathematics Anxiety scale. Like confidence levels, anxiety is also cited as a reason for gender differences in mathematics.

Anxiety will be discussed further in Section 2.5 on emotions regarding mathematics.

## ***2.5 Literature on Emotions toward Mathematics***

Literature dealing solely with emotions about mathematics is relatively scarce compared to the vast research on attitudes and beliefs. Much of the literature on mathematical emotions is incorporated into research on attitude to mathematics although technically they are two separate affective issues. This section outlines the theoretical background for emotions regarding mathematics, as well as a review of the available literature on emotions/feelings about mathematics.

### 2.5.1 Theory of Emotions

Hannula (2002) suggests that emotions, together with a person's expectations and values are the basis for attitude formation. Emotions differ from attitudes however, in that they cause a more intense or immediate reaction or as Mandler's constructivist theory (1989) states "*a gut reaction to a discrepancy of an expected schema*". According to Hannula, when a student is engaged in mathematical activity, there is a continuous unconscious evaluation of the situation with respect to personal goals. Proceeding towards these goals produces a positive emotion, while obstacles evoke a negative emotion. Op 'T Eynde et al. (2006) stress the importance of *sensitive dependence on initial conditions* in an emotional experience. They suggest that emotional experiences or responses can vary not only according to the social context (e.g. mathematics classroom v. English classroom) but are also influenced by the knowledge and beliefs held by the individual. Although emotions interact with attitudes and beliefs regarding mathematics, they differ to attitudes and beliefs, as they "*may change rapidly*" according to McLeod (1992). Emotions are an integral aspect of learning. Kort et al. (2001) proposed a model relating phases of learning to selected emotions (cited in Liston, 2009). The model proposes four phases of learning and emotions as follows:

1. Constructivist learning with positive affect/emotions (awe, satisfaction, curiosity).
2. Constructivist learning with negative affect/emotions (disappointment, puzzlement, confusion).
3. Un-learning with negative affect/emotions (frustration, discard, misconceptions).
4. Un-learning with positive affect/emotions (hopefulness, fresh research).

Kort et al. use this model to illustrate the range of emotions involved in a learning experience.

In the literature, the most widespread emotion regarding mathematics is that of mathematics anxiety.

### 2.5.2 Anxiety about Mathematics

Hoyles (1982) suggests that explanations for mathematics anxiety are divided into three classes:

1. Explanations derived from the nature of the subject mathematics.
2. Explanations based on the influence of past experiences and the self-concept of ability in mathematics.
3. Explanations concerned with how mathematics is taught and learnt in schools.

Evidence of the three explanations of anxiety proposed by Hoyles can be found in the literature.

The first explanation deals with a general anxiety regarding mathematics. In her study of 14-year old students' views of mathematics, Hoyles (1982, p.368) found that students' feelings about mathematics tend to be negative. Anxiety and panic regarding mathematics can actually block more positive emotions (Ruffell et al, 1998, p.3). Hodges (1983) completed a study that looked at why some young people succeed while others fail in mathematics. Hodges reported that the result of the study was a "not-too-uncommon illness", mathophobia. Mathophobia is an excessive fear of mathematics. Poor performance, low motivation, fear of failure, ridicule, misunderstandings, and a dislike of mathematics are among the symptoms of mathophobia. Often, people who suffer from mathophobia are actually capable of understanding and succeeding in mathematics. For them, however, like many other phobias, a past experience has resulted in an irrational fear of the subject which is consequently avoided when possible.

The second explanation for mathematics anxiety refers to one's self-concept in mathematics and originating from past experiences of mathematics. As noted in Section 2.4.2, mathematics anxiety in the literature is clearly associated with self-confidence in mathematics, as low self-confidence in one's mathematical ability is clearly linked with higher anxiety levels regarding mathematics (Fennema & Sherman, 1976). Hembree's (1990) meta-analysis of 151 studies regarding mathematics anxiety indicated that females' anxiety regarding mathematics is

consistently higher than that of males. As in the case of self-concept, anxiety about mathematics has been at the heart of much of the literature on gender differences in mathematics. The research study by Pedro et al. (1981) highlighted anxiety as influencing the mathematical plans of males and females, with gender differences occurring (see Section 2.2.4). The relationship between anxiety and performance in mathematics is highlighted in Perkins et al. (2007). Examining students' performance in PISA, Perkins et al. found that students with the highest anxiety levels had the lowest scores. In all countries (including Ireland) except Poland and Serbia, male students reported significantly lower levels of anxiety than female students. This coincides with males outperforming females in 21 of the 29 countries which took part in the PISA study. Leder (1980) also points out the possible relevance of Horner's FS theory (1968) to sex differences in mathematical achievement. FS theorizes that success can produce anxiety in some women, especially in areas which are considered by society to be less appropriate for females. It is this anxiety, although not apparent in all cases, which can result in poor performance for women in mathematics. Without confidence in their abilities, and with increased anxiety levels associated with mathematics, women continue to believe that they cannot do mathematics as well as men. Past experiences of mathematics leading to negative emotions regarding mathematics are dealt with in Section 2.6.

The final explanation of mathematics anxiety regards learning mathematics and how mathematics is taught. Fennema & Sherman (1976) note that anxiety can be debilitating and prevent one from learning. Lim (1999) found that many people who reported a dislike of mathematics tended to feel unsure, worried and nervous when they thought of learning mathematics at school. In addition, Lim found that 10-13% more women than men expressed this view. Hoyle's (1982) interviews with students illustrated that bad experiences of learning mathematics were commonly associated with feelings of anxiety, inadequacy and shame.

As seen from the literature on mathematics anxiety, past experiences of mathematics and learning mathematics play a significant role in creating negative



emotions regarding mathematics. The influence of past experiences on all aspects of images of mathematics is discussed in Section 2.6.

## ***2.6 Literature on Past Experiences and Factors of Influence***

The influence of past experiences of mathematics on a person's image of mathematics is evident from the literature and as seen in Section 2.1.1, many researchers refer to past experiences in their definitions of 'image of mathematics'. In this section, we look at the literature on past experiences regarding mathematics, as well as other possible factors which can influence a person's image of mathematics.

### **2.6.1 Past Experiences of Mathematics**

The influence of past experiences of mathematics on attitudes, beliefs, self-concept, emotions and ultimately on our image of mathematics is a recurrent theme in much of the literature. In relation to image specifically, Lim (1999) supports the view that that past experiences are vital components in the image formation process. Her findings also suggest that past experiences of learning mathematics might influence a person's motivation to continue learning mathematics at a higher level. In Brown's (1995) definition of 'image of mathematics', experience is highlighted together with feelings, expectations and confidences, while Eaton & O'Reilly (2009) in their study of student teachers' mathematical identity, stress the importance of experience in an individual's relationship with mathematics. In her study of pupils' views of mathematics, Hoyles (1982) observed that learning experiences in mathematics tended to provoke a stronger reaction than in other school subjects. In addition, Hoyles found that 63% of students' stories on learning mathematics related to bad experiences.

With regards to attitudes towards mathematics, Lyons et al. (2003) note the persistent influence that any bad experience with mathematics can have on students' attitudes towards their future learning. Ruffell et al. (1998), in their study on attitudes to mathematics, discovered that a specific past experience or memory of mathematics

(usually a negative one) can override and dominate more general positive feelings towards mathematics. The importance of experience as an influence on an individual's beliefs about mathematics is seen in Hannula (2007). Hannula states that new experiences can challenge old beliefs, suggesting a strong relationship between beliefs and experience in mathematics. Past experiences are particularly significant in the research on self-concept/self-efficacy in mathematics. For example, Smith (1996) confirms that one's history of perceived past successes and failures plays a major role in shaping our efficacy beliefs. Sax (1992) found mathematical confidence to be most strongly predicted by second-level experiences (as noted in Section 2.4.2). Furthermore, Hoyle's (1982) study showed that a much larger proportion of students' stories (past experiences) expressed negative feelings about self in mathematics compared with other school subjects (42.7% compared with 24.3%). Finally, in relation to feelings about mathematics, Hoyle's study indicated that students' bad experiences of mathematics led to feelings of anxiety, inadequacy and shame. Hodges (1983) showed how a negative past experience of mathematics can result in mathophobia – an excessive fear of mathematics. The importance of past experience as influencing teachers' attitudes, beliefs and self-concept is stressed in Philippou & Christou (1998). Mathematics teachers with a negative image of mathematics or low self-concept of ability in mathematics can pass this negative image on to their students which can develop into a vicious circle if any of these students in turn become teachers.

Experiences of mathematics as influences on our image development can be primary or secondary according to Lim (1999). Primary experiences consist of our own observations and personal experiences of mathematics. Secondary experiences refer to those which we have been told or have read about. As our experiences change and more recent memories usurp older ones, so too can our image of mathematics be altered or a new image may be formed. However, as Lim remarks, if we stop experiencing something then our image of it might remain unchanged for a long time.

Related closely to past experiences of mathematics are a number of other factors which can have an influence in the formation of an image of mathematics. These are discussed in the following section.

### **2.6.2 Factors of Influence**

From a review of the literature, the four main factors that influence the formation of an image of mathematics are:

- Teachers
- Parents
- Peers
- Society.

These factors can have a varying degree of influence on a person's image of mathematics. Lim (1999), in her study on public images of mathematics describes these factors as the external factors of influence, while the main internal factor of influence is the 'self'. As self-concept has already been covered in this literature review in Section 2.4, this section will focus on the four external factors of influence.

#### **Influence of Teachers:**

Both primary and post-primary teachers involved in the mathematics teaching process are factors of influence. Lim (1999) found that teachers had the most influence on people's image of mathematics. Philippou and Christou (1998, p.189) acknowledge that teachers' beliefs and conceptions about mathematics are a vital factor in the process of teaching and learning. The importance of teachers in influencing students' learning experiences is emphasized in Hoyles (1982). She found that 22% of negative stories of mathematics related to teacher pace and/or pressure. Experiences concerned with teacher-imposed pressure associated with learning mathematics were found to be commonly associated with feelings of inadequacy and lack of confidence. Dweck (1986) and Lyons et al. (2003) have expressed concern that teachers' views of students' ability can affect students' performance. Fennema et

al. (1990) and Fennema (1990) highlight the differences in teachers' expectations of girls and boys in mathematics which can lead teachers to overrate boys' mathematical capability and to underrate that of girls'. Brown (1992) found that different teachers with differing teaching approaches can generate distinct images of mathematics for their students. As seen in Lim (1999), people generally do not distinguish their image of mathematics from their image of learning mathematics and therefore teachers will play a significant role in this context. This is advocated by Ernest (1996) who states that "*experiences in school mathematics form the basis for the image of mathematics constructed by learners, especially negative ones*".

### **Influence of Parents:**

The influence of parents in forming an image of mathematics can be seen from the literature. As well as parents, influence may come from guardians, siblings, other family members and the general home environment. Reynolds & Wahlberg (1992) found that home environment had an indirect effect on achievement in mathematics, particularly in terms of motivation in mathematics. Lim (1999) found parents to be the second most common influence in forming an image of mathematics. In particular, she found fathers to have more influence than mothers. The differentiation between the influence of the father and the mother is also evidenced in Fennema & Sherman (1976) in the development of their Mathematics Attitude Scales. A separate scale is devised for the perception of the father's attitude towards the student as a learner of mathematics and the perception of the mother's attitude. Fennema & Sherman suggest that parents can influence their children differently, with fathers having a key role in certain kinds of cognitive development. Parental influence appears to be found mostly in the form of moral support and encouragement (Lim, 1999). Indeed, Hanna et al. (1991) identify parental support as having the greatest influence on mathematical performance. If parents view mathematics as a valuable subject and encourage their children to study it, this can have a direct influence on their children's image of mathematics. However if parents have a negative image of mathematics and do not encourage their children to study it, this can also have an impact on their children's image of mathematics.

### **Influence of Peers:**

Lim (1999) found peer support to be an influential factor for some adults' images of mathematics. She found that out of 36 adults who claimed to like mathematics, 8 referred to the influence of their peers, with many adults who liked mathematics tending to mix with peers who also liked and/or were good at mathematics. Similarly, for those who claimed to dislike mathematics, they tended to associate with peers who also disliked mathematics. The one exception to this in Lim's sample claimed that her friends who liked and were good at mathematics made her feel inferior because she found mathematics difficult. In Hill's (2008) study on the mathematical identity of college students, she discovered that each of the students agreed that they learned mathematics much better working in groups and discussing mathematics with their peers rather than working alone. Her study highlights the importance of social interaction and peer support in a learning environment such as a mathematics class.

With regards to post-primary students, research has shown that peer popularity is particularly important during adolescence. Simkin (1979) found that girls tended to value peer-popularity above academic success which would have implications for all school subjects including mathematics. Kogelman & Warren (1978) suggest that girls may feel that by choosing to further study mathematics (a masculine subject), they will appear less feminine. This is contradicted however by an empirical study by Kaiser-Messmer (1993) who found that since the 1980s, girls' views on the mathematical ability of women and acceptable gender roles have changed significantly. Instead, boys were found to adhere more to gender-typical roles. Although, as seen in Section 2.3.4, gender differences in mathematical beliefs have indeed been altered in recent years, it is clear that peers can still have some influence on students, particularly during the teenage years.

### **Influence of Society:**

We have already seen the significance of cultural myths or stereotypes that have become widespread in society (see Section 2.3). In addition to this, mathematical representations by the media have the power to positively or negatively affect the image of mathematics both in Ireland and internationally. Mendick et al. (2008, p. ii) reported that mathematical representations in popular culture are both invisible and ubiquitous. The report also found that popular cultural texts strongly support the association of mathematics with masculinity, whiteness, middle-classness and heterosexuality, and the ‘genius’ of mathematicians is seen to set them apart from others. Examples of mathematics found in the media in Ireland are as follows:

- Television or Radio Programmes; e.g. *The Krypton Factor* TV3.
- Film; e.g. *A Beautiful Mind*; *Good Will Hunting*.
- Puzzles and Crosswords; e.g. Sudoku, the *Irish Times* Crossword.
- Websites; e.g. [www.coolmath.com](http://www.coolmath.com) ; [www.mathsisfun.com](http://www.mathsisfun.com)
- Newspaper and Magazine Articles.

Much of the mathematics which appears on our television screens or in our newspapers is school mathematics, particularly when exam results are published, but in general there is little visible evidence of mathematics in our popular media. The importance of public or societal influence is advocated in Galbraith & Chant (1990) who suggest that the goals of mathematics education can be pressured by political, social and economic forces that are often expressed through the medium of public opinion.

Finally, a number of cross-cultural research studies have been carried out on different aspects of ‘image of mathematics’, in particular in relation to attitudes to mathematics and beliefs about mathematics, and these studies illustrate the varying influence of different cultures or societies. A study by Andrews & Hatch (2000) examined English and Hungarian teachers’ conceptions of mathematics and mathematics teaching. While a number of similarities were found between the two, one significant difference existed. While English teachers were aware of the utility to

commerce and industry of the mathematics which they taught, Hungarian teachers tended to focus on the pedagogical relevance of the mathematics taught. Cultural differences were also found by Clarkson & Leder (1984) in a study on the causal attribution of success and failure by students in Papua New Guinea and Australia. Results showed that students from Papua New Guinea were more likely to attribute failure to an unstable factor such as effort or luck than were students from Australia, with cultural differences between students found to be more significant than gender differences. This is similar to findings from the Second International Mathematics Study in which differences in mathematical performance between countries were greater than between genders (Hanna, 1989). Pehkonen's (1996) international comparative pilot study on students' beliefs found that differences between countries were more frequent than differences between genders. Gender differences may also be culture specific as evidenced in Byrnes et al. (1997). A sample of Chinese students were tested on items from the mathematics subtest of the Scholastics Aptitude Test (SAT) that had been found to produce the greatest gender differences among American students. Their study found no significant differences on these test items between Chinese male and female students. The Programme for International Student Assessment (PISA) and the Trends in International Mathematics and Science Study (TIMSS) have also provided a basis for assessing differences in mathematical performance between countries. A review of these studies highlights the importance of societal and cultural influence on mathematics performance as well as on a person's image of mathematics.

## **2.7 Summary**

In summary, a review of the literature indicates that the image of mathematics is a topic of importance and relevance on both an Irish and international level. In spite of the lack of research studies which examine this topic specifically, the elements of attitudes, beliefs, self-concept, emotions and past experiences regarding mathematics have received significant attention from researchers in mathematics education.

Although the literature displays some confusion in terms of defining ‘image of mathematics’, ‘attitudes’ and ‘beliefs’, it is evident that there has been considerable changes in these areas in recent times, influenced in particular by societal changes and the development of newer and improved research techniques. One of the most dramatic changes has occurred in the area of gender differences, with research indicating that the remaining variance between the sexes in mathematics is most likely explained in relation to self-concept and/or anxiety in mathematics.

The images of mathematics emerging from the literature highlight an emphasis on a ‘dualistic’ image which can be sourced from the education system. There also appears to be little distinction between mathematics as a concept and mathematics teaching and learning in peoples’ images of mathematics. Despite the aforementioned changes in mathematical attitudes and beliefs, there remains a strong public image of mathematics which adheres to the older cultural stereotypes.

The literature underlines the importance of past experiences in forming an image of mathematics as well as the significant role played by teachers, parents, peers and society in influencing a person’s image of mathematics although more up-to-date research on these is required.

This literature review suggests the need for more rigorous definitions in mathematics education research, in particular regarding attitudes, beliefs, emotions and images of mathematics. While these may be open to individual interpretation, care must be taken when comparing research studies as results can be invariably influenced by differences in the definition of terms used.

Finally, there is also a need for more research on the experience-image formation process as past experiences are clearly a major influence on a person’s image of mathematics. The literature also highlights the lack of research in Ireland compared to other countries regarding the affective issues in mathematics education.



## **Chapter Three**

### **Theoretical Framework for Image of Mathematics**

## Chapter Three: Theoretical Framework for Image of Mathematics

This chapter outlines the theory underpinning this research thesis, including definitions of the terms used in this study. We draw on the previous chapter's review of the relevant literature in order to conceptualise 'image of mathematics' as understood in our research study.

### 3.1 Definition of 'Image'

Image can have different meanings for different people. Some dictionary definitions for 'image' include:

- A mental picture of something not real or present (The American Heritage Dictionary, 2009);
- The opinion or concept of something that is held by the public or, the character projected to the public, as by a person or institution, especially as interpreted by the mass media (The American Heritage Dictionary, 2009);
- The mental experience of something that is not immediately present to the senses, often involving memory (Collins English Dictionary, 2003).

Thus an image may relate to a mental picture, or be the general impression that a person, organization, or product presents to the public, or it may be a "*belief, assumption or expectation*" held by an individual (Picker & Berry, 2000, p.67). Lim (1999) uses the following definition of 'image' in her study:

*"A mental representation (not necessarily visual) of something, originated from past experience as well as associated beliefs, attitudes and conceptions"*

This is the definition of 'image' adopted in our study. As an image originates from past experiences, it can comprise both affective and cognitive dimensions. Affectively, it is associated with attitudes, emotions and feelings, whilst cognitively it relates to a person's knowledge, beliefs and other cognitive representations (Lim, 1999).

### **3.2 Definition of ‘Mathematics’**

Mathematics as a universal language is a powerful means of communication (The Cockcroft Report, 1982, p.3). Barton (2008, p.169) defines mathematics as a *“system created by humans to help them understand their experiences of quantity, relationships and space”*. Courant et al. (1996) describe mathematics as an expression of the human mind which reflects active will, contemplative reason and the desire for aesthetic perfection. Lim (1999) states that mathematics functions as an analytical tool and stimulates logical thinking, but she also concludes that many people would define mathematics as *“not more than numeracy, restricted mental arithmetic and everyday mathematics”*.

There appears to be some confusion between the terms mathematics and numeracy as there is no universal definition of numeracy. O’Donoghue (2002, p.47) asserts that Ireland had no explicit definition of numeracy in the early nineties despite its widespread currency in official reports and educational documents. Hansen (2003) defines numeracy as the mathematical knowledge, skills, and understanding that every person in principle needs to have in a given society at a given time. O’Donoghue (2002, p.48) supports the view that numeracy includes *“basic computational arithmetic, essential mathematics, social mathematics, survival skills for everyday life, quantitative literacy, mathematical literacy and an aspect of mathematical power”*. A recent report entitled Literacy and Numeracy for Learning and Life (2011) issued a definition of numeracy as *“not limited to the ability to use numbers, to add, subtract, multiply and divide”*. It continues that numeracy *“encompasses the ability to use mathematical understanding and skills to solve problems and meet the demands of day-to-day living in complex social settings”*. Thus, numeracy requires the ability to *“think and communicate quantitatively, to make sense of data, to have a spatial awareness, to understand patterns and sequences, and to recognize situations where mathematical reasoning can be applied to solve problems”*. This is the understanding of numeracy for this study.

Mathematics, on the other hand, is more than numeracy. For this study, we follow the definition of mathematics given by Barton (2008) as a system to understand quantity, relationships and space. In addition to Barton's definition, we also include the understanding of mathematics as a discipline of study. We include mathematics as a discipline of study in our chosen definition of 'mathematics' because of the findings of Lim (1999) in which the majority of people did not seem to distinguish their image of mathematics from their image of learning mathematics. As this study is aimed at post-primary students, we anticipate that this may also be the case for our sample. Therefore our definition of mathematics also incorporates mathematics learning.

### **3.3 Definition of 'Image of Mathematics'**

From the literature, it is clear that no universal definition exists for 'image of mathematics'. However, for those researchers who define 'image of mathematics' (either explicitly or implicitly), there appears to be a general consensus that it should include attitudes, beliefs, self-concept, emotions and past experiences regarding mathematics. For our definition of 'image of mathematics', we draw on the theories of Lim (1999) and Wilson (2011).

As noted in Section 2.1.1, Lim (1999) combines the definitions of Thompson (1996a) and Rogers (1992) to conceptualize the term 'image of mathematics' as "*a mental representation or view of mathematics, presumably constructed as a result of social experiences, mediated through school, parents, peers or mass media. This term is also understood broadly to include all visual and verbal representations, metaphorical images and associations, beliefs, attitudes, and feelings related to mathematics and mathematics learning experiences*". Lim divides the elements included in her definition of 'image of mathematics' into two categories: the affective domain which refers to attitudes, emotions and feelings regarding mathematics, and the cognitive domain which refers to knowledge and beliefs regarding mathematics. Wilson's (2011) theory of 'disposition' has similarities with the construct of 'image of mathematics' in the literature. His definition of 'disposition' overlaps to a certain

degree with Lim's definition of 'image of mathematics'. In his definition he proposes four components to disposition as follows:

- *Beliefs / values / identities.*
- *Affect / emotions.*
- *Behavioural intent / motivation.*
- *Needs: relating to Maslow's hierarchy (1970).*

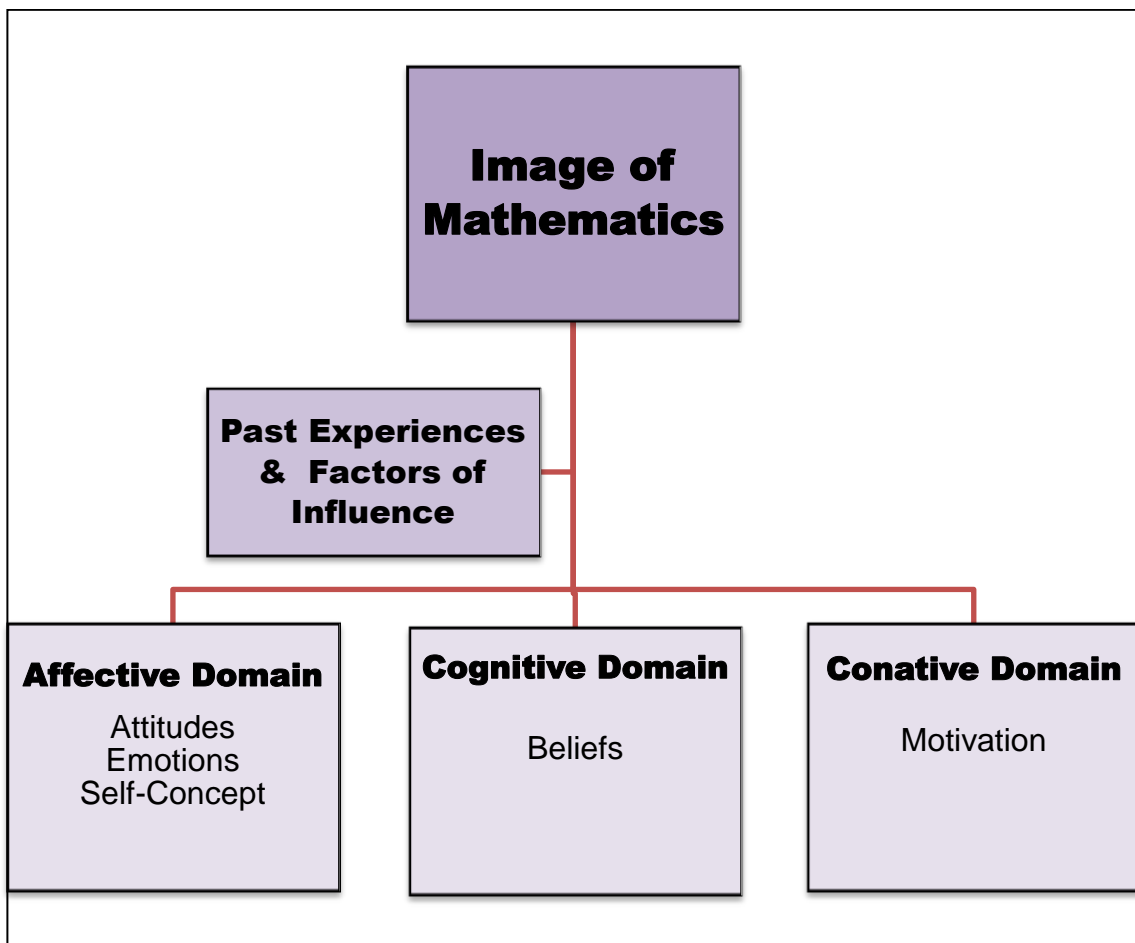
The first two components coincide with Lim's definition of 'image of mathematics', while the fourth component 'needs' is similar to the factors of influence included in Lim's theory and which are outlined in the previous chapter in Section 2.6.2. The third component refers to the conative domain proposed by Ruffell et al. (1998). Ruffell et al. suggested that a conative element works together with the affective and cognitive domains. Although the study by Ruffell et al dealt with a multi-dimensional theory of 'attitude', Wilson applies their theory to his construct of 'disposition'. In particular, the behavioural intent of the conative domain is assessed with regards to motivation in mathematics.

In this thesis we adapt the definitions of Lim (1999) and Wilson (2011) for our study, with 'image of mathematics' conceptualized as follows:

*A mental representation or view of mathematics, presumably constructed as a result of past experiences, mediated through school, parents, peers or society. This term is also understood broadly to include three domains:*

- *The affective domain dealing with attitudes, emotions, and self-concept regarding mathematics and mathematics learning experiences.*
- *The cognitive domain dealing with beliefs regarding mathematics and mathematics learning experiences.*
- *The conative domain dealing with motivation regarding mathematics and mathematics learning.*

Self-concept is not included in the definitions of Lim or Wilson, but following our literature review which indicates the increasing significance of self-concept regarding mathematics, it was decided that self-concept should be included in the affective domain of our definition for ‘image of mathematics’. Our construct for ‘image of mathematics’ is outlined in Figure 3.1.



**Figure 3.1: Image of Mathematics**

In the next section – Section 3.4 – we define our understanding of each of the elements of ‘image of mathematics’ for this research study.

### **3.4 The Affective, Cognitive and Conative Domains**

In this section we look at each of the three domains of affective, cognitive and conative, providing definitions of attitudes, emotions, self-concept, beliefs and motivation as understood in this thesis.

#### **3.4.1 The Affective Domain**

Affective issues in mathematics education have received considerable attention from researchers; see for example McLeod (1994), Hannula (2007), and Liston & O'Donoghue (2007). In particular attitudes towards mathematics have been at the centre of mathematics education research since the 1970s, closely followed by emotions regarding mathematics. Self-concept in mathematics emerged as a significant concern from the 1980s, with researchers becoming increasingly interested in examining self-concept in the recent decade. This section outlines the theoretical basis for understanding each of these affective elements in this study.

##### **Attitude towards Mathematics:**

From the literature, the definition of 'attitude' which best fits our research and which adheres closely to the general understanding regarding attitude definitions (see Section 2.2.1) is that of Aiken (1970) who states that attitude is "*a learned predisposition or tendency on the part of an individual to respond positively or negatively to some object, situation, concept, or another person*". In order to fit Aiken's definition of attitude more closely within the guidelines of Fishbein & Ajzen (1975), we adapt Aiken's definition to include attitude as being relatively stable:

*A learned predisposition or tendency, which is relatively stable, on the part of an individual to respond positively or negatively to some object, situation, concept, or another person.*

Thus adjusting this definition for attitude towards mathematics we have:

*A learned predisposition or tendency, which is relatively stable, on the part of an individual to respond positively or negatively to mathematics.*

### **Emotions about Mathematics:**

To understand the theory behind emotions, we draw on the work of Mandler (1989) and Hannula (2002). Mandler's constructivist theory of emotion (i.e. Mandler, 1989) sees emotion as a gut reaction to a discrepancy of an expected schema, which is followed by a cognitive analysis. Mandler's theory also asserts that emotions express some aspect of value. The value aspect together with the discrepancy creates various emotional responses. Hannula (2002) conceptualizes emotion and cognition as two complementary aspects of the mind. He suggests that from the research, there are three characteristics of emotion:

- 1. Emotions are seen in connection to personal goals.*
- 2. Emotions are seen to involve a physiological reaction.*
- 3. Emotions are seen as functional i.e. have an important role in human coping and adaption.*

Furthermore, Buck (1999) asserts that emotions have three mutually independent readouts (cited in Hannula, 2002):

- 1) Adaptive-homeostatic arousal responses (e.g. releasing adrenaline into the blood)*
- 2) Expressive displays (e.g. smiling)*
- 3) Subjective experience (e.g. feeling sad).*

Based on these theories of emotion by Mandler and Hannula, we adopt the following understanding of emotion for this study:



*Emotions are a gut reaction to a discrepancy of an expected schema. They involve a physiological reaction that enables us to cope and adapt to any discrepancy in achieving personal goals. Emotions appear in three independent forms: arousal responses; expressive displays; and subjective experience.*

Dealing with emotions regarding mathematics, our understanding is adapted as follows:

*Emotions in mathematics are a gut reaction to a discrepancy of an expected schema with regards to mathematics and mathematics learning. They involve a physiological reaction that enables us to cope and adapt to any discrepancy in achieving personal goals relating to mathematics and learning mathematics. Emotions appear in three independent forms: arousal responses; expressive displays; and subjective experience.*

### **Self-concept in Mathematics:**

As seen in Section 2.4.1, Drew & Watkins (1998) define self-concept as “a psychological construct which refers to the cluster of ideas and attitudes an individual holds about himself”. Self-concept is often used synonymously with self-belief or self-efficacy and ties in with self-confidence. The general consensus in the literature is that self-concept deals with attitudes and beliefs about the self and one’s ability.

Regarding mathematics specifically, we follow the definition of mathematical self-concept asserted by Gourgey (1982). As such, we understand self-concept in mathematics for this study as:

*The beliefs, feelings or attitudes regarding one’s ability to understand or perform in situations involving mathematics.*

### 3.4.2 The Cognitive Domain

The cognitive domain, from the literature, tends to deal with knowledge and beliefs regarding mathematics. However, as we mentioned in Section 2.3.1, beliefs are individual constructs while knowledge is essentially socially constructed (Op't Eynde et al., 2002). As we are interested in examining the image of mathematics of individuals, beliefs are therefore more relevant to our study. In addition, the majority of the literature on beliefs research agrees that beliefs interact to some degree with the affective issues of attitude and emotion and as such, beliefs can be seen as more of a complementary aspect to the affective domain than knowledge. Consequently, we focus on beliefs within the cognitive domain of 'image of mathematics'.

#### **Beliefs about Mathematics:**

From the literature, theories regarding beliefs are very much divided into two categories: theories placing beliefs within the affective realm, and theories that place beliefs within the cognitive domain together with knowledge. In this study, we theorize beliefs as part of the second category, as a cognitive construct.

For this research study, we combine the definitions of Fishbein & Ajzen (1975) and Furinghetti & Pehkonen (2002). Fishbein & Ajzen define belief as "*the subjective probability of a relation between the object of the belief and some other object, value, concept or attribute*". Furinghetti & Pehkonen define beliefs as the subjective, individually constructed, experiential and tacit knowledge of the individual. Combining these definitions and relating them to mathematics specifically, we emerge with the following understanding of mathematical beliefs for this study:

*The subjective probability of a relation between mathematics and some other object, value, concept or attribute which is experience-based and constructed by an individual.*

### 3.4.3 The Conative Domain

There is relatively little evidence of the conative domain in the mathematics education literature compared with the affective and cognitive domains. Conative issues such as motivation were traditionally considered as an attitude dimension (see for example Fennema & Sherman, 1976) or as an aspect of beliefs (see Hill, 2008). The conative domain has emerged in the last decade or so as an independent concept dealing with behavioural intent (Ruffell et al., 1998; Tait-McCutcheon, 2008; Wilson, 2011). Within the conative domain, we focus on motivation in mathematics, as this is the most viable measure for assessing behavioural intent with regards to mathematics.

#### **Motivation in Mathematics:**

According to Middleton & Spanias (1999), “*motivations are reasons for behaving in a given manner in a given situation*”. Ames (1992) states that motivations exist as part of one’s goal structures, one’s beliefs about what is important, and they determine whether or not one will engage in a given pursuit (cited in Middleton & Spanias). From the literature, motivations tend to be divided into two categories: intrinsic motivation and extrinsic motivation. Individuals who are intrinsically motivated tend to focus on ‘learning goals’ while individuals who are extrinsically motivated tend to focus on ‘performance goals’ (see Dweck, 1986, Middleton & Spanias, 1999, Breen et al., 2007). Motivation theories are intrinsically linked with success and failure, and motivation in mathematics is no different (Middleton & Spanias).

For this study, we follow the basic definition of Middleton & Spanias (1999) with motivation viewed as:

*The reasons for behaving in a given manner in a given situation.*

We also adhere to the understanding of motivation in Dweck (1986) where motivational goals are divided into two categories:

- 1) *Learning Goals: the individual seeks to increase their competence, to understand or to master something new.*
- 2) *Performance Goals: the individual seeks to gain favourable judgements of their competence or avoid negative judgements of their competence.*

Combining the definition of Middleton & Spanias with the theory of Dweck, we adopt the following understanding of motivation in mathematics:

*Motivation in mathematics deals with the reasons for behaving in a given manner in a given situation. These reasons are linked to motivational goals in mathematics which are either:*

- 1) *Learning goals in which the individual seeks to increase their competence or understanding in mathematics, or*
- 2) *Performance goals in which the individual seeks to gain favourable judgement of their mathematical competence or wishes to avoid negative judgements of their mathematical competence.*

### **3.5 Summary of Theoretical Framework**

This section provides a summary of the theoretical framework for our study and is outlined in Figure 3.2.

Combining the definitions and theories described and adopted in this chapter, we have the resulting theoretical framework for our investigation into the image of mathematics held by 5<sup>th</sup>-year post-primary students in Ireland.

***Image of Mathematics:*** Definition adapted from Lim (1999) and Wilson (2011).

***Affective Domain:***

***Attitudes:*** Definition adapted from Aiken (1970) and Fishbein & Ajzen (1975).

***Emotions:*** Based on the theory of Mandler (1989) and Hannula (2002).

***Self-concept:*** Definition of Gougeon (1982).

***Cognitive Domain:***

***Beliefs:*** Definitions of Fishbein & Ajzen (1975) and Furinghetti & Pehkonen (2002) combined.

***Conative Domain:***

***Motivation:*** Definition of Middleton & Spanias (1999) combined with the theory of Dweck (1986).

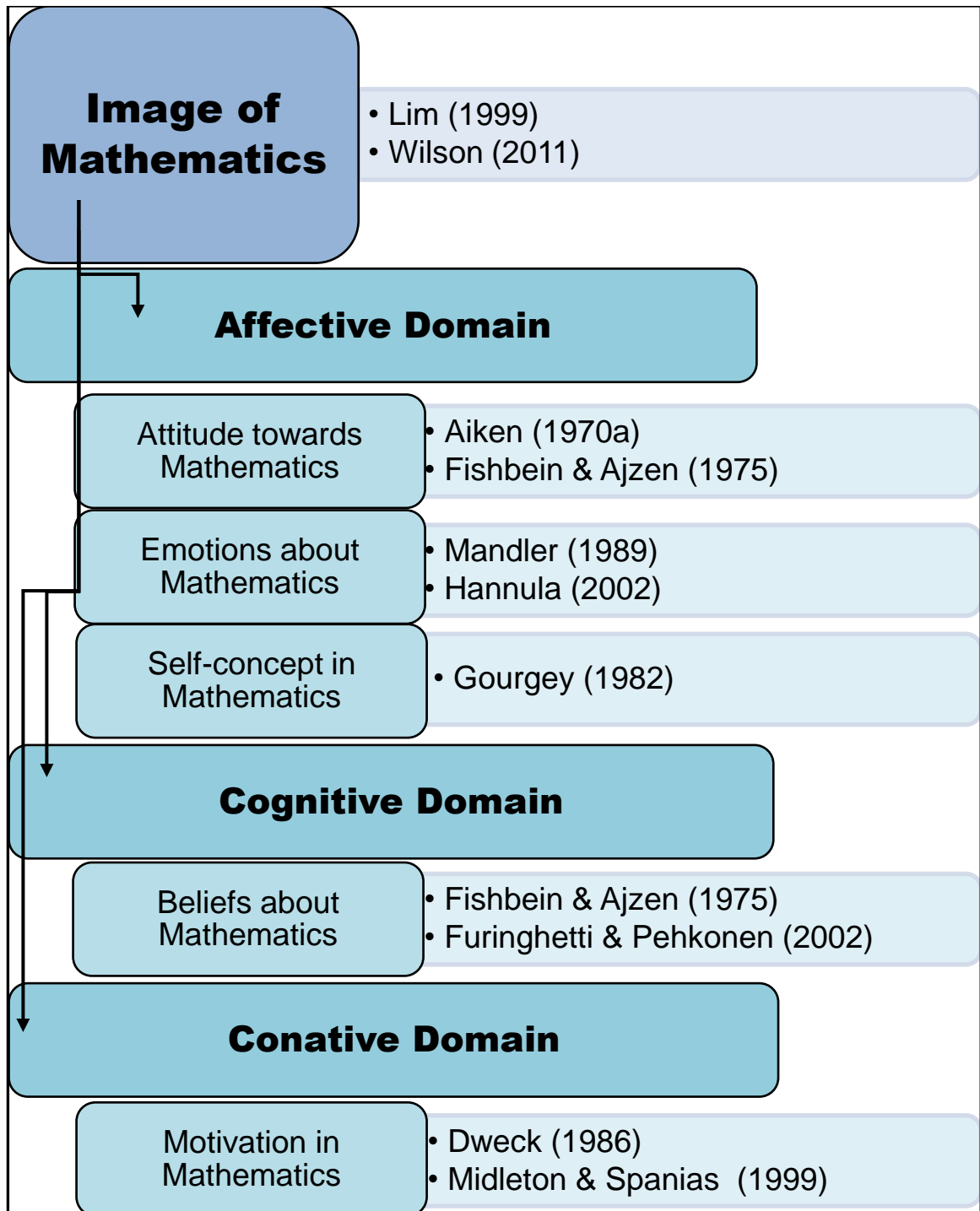


Figure 3.2: Theoretical Background for 'Image of Mathematics'

### 3.6 Research Questions

A number of research questions emerged from the review of the literature on images of mathematics and related topics. These questions were then refined through the theoretical framework chosen for this study. The main research question for this research study is:

- ❖ *What is the image of mathematics held by 5<sup>th</sup>-year post-primary students in Ireland?*

Following an examination of previous research on images of mathematics, as well as the elements of attitudes, beliefs, self-concept, emotions, motivation, past experiences and factors of influence which are included in our understanding of images of mathematics, several more questions seem relevant to this PhD study. Therefore, in addition to the main research question above, we add nine more research questions, or sub-questions. The first five in particular, might be considered as a subset of the initial research question on image of mathematics, while the following four are intended to elaborate on our understanding of the image of mathematics held by 5<sup>th</sup>-year post-primary students in Ireland.

- ❖ *Do 5<sup>th</sup>-year post-primary students in Ireland have a positive or negative attitude toward mathematics?*
- ❖ *What feelings/emotions do 5<sup>th</sup>-year students in Irish post-primary schools associate with mathematics?*
- ❖ *Do 5<sup>th</sup>-year post-primary students in Ireland have confidence in their mathematical ability?*
- ❖ *What beliefs do Irish post-primary 5<sup>th</sup>-year students hold about mathematics?*
- ❖ *Are 5<sup>th</sup>-year post-primary students in Ireland motivated regarding mathematics?*
- ❖ *Do their past experiences of mathematics impact 5<sup>th</sup>-year post-primary students' current images of mathematics?*
- ❖ *Who influences Irish 5<sup>th</sup>-year post-primary students most in terms of mathematics and the formation of their image of mathematics?*

- ❖ *What are the causal attributions of Irish post-primary students in 5<sup>th</sup>-year for success and/or failure in mathematics and do gender differences occur?*
- ❖ *Is there a relationship between 5<sup>th</sup>-year post-primary students' images of mathematics and their prior achievement in mathematics?*



## **Chapter Four**

### **Methodology**

## Chapter Four: Methodology

The aim of this research study is to investigate the image of mathematics held by 5<sup>th</sup>-year post-primary students in Ireland. According to the theoretical framework for ‘image of mathematics’ chosen for this study (see chapters 2 and 3), we will examine the attitudes, emotions, self-concept, beliefs, motivation and past experiences of students. In this chapter we outline the research design for this study. This chapter also describes the rationale behind the selected research methodology. We look at the methods employed in this study and the sampling methodology chosen in the main data collection stage. Finally, we outline the validity, reliability and limitations of the study.

### 4.1 Research Design

In this section we discuss the purpose and characteristics of research and, in particular, we examine the features of educational research. We look at the design process in research and outline the research design for this study.

#### 4.1.1 What is Research?

Leedy and Ormrod (2001) define research as the “*systematic process of analysing information or data with a view to increasing our understanding of the phenomenon about which we are concerned or interested*”. For this research thesis, we aim to increase our understanding of the image of mathematics held by 5<sup>th</sup>-year post-primary students in Ireland. Research has a basic purpose, that is, to add to the existing body of knowledge. In terms of research in education specifically, it can have two functions (Wiersma, 1991):

- 1) To expand knowledge
- 2) To find a solution to a problem.

This research project falls chiefly into the first category: to expand our knowledge regarding the image of mathematics of post-primary students. Wiersma adds that the overall function of educational research is to improve the educational process through

the refinement and extension of knowledge. No previous research has examined the image of mathematics held by post-primary students in Ireland. Therefore this research study aims to extend our knowledge regarding post-primary students in Ireland in relation to mathematics: This will benefit the mathematics education community.

#### **4.1.2 The Classical Research Cycle**

The traditional view of the research process is that of a cycle whose developmental steps, taken from Leedy & Ormrod (2001, p.8) are outlined in Figure 4.1 below. During this cycle, the researcher considers and reconsiders every aspect of the process. Even within the research cycle, insights (including those caused by failure or chance observation), may cause a reformulation of underlying theories or of what are considered the prominent questions. However Leedy and Ormrod (2005) caution that research is rarely conclusive and that rather than a closed circle, research might more aptly be viewed as a spiral, leading to even more research with each step.

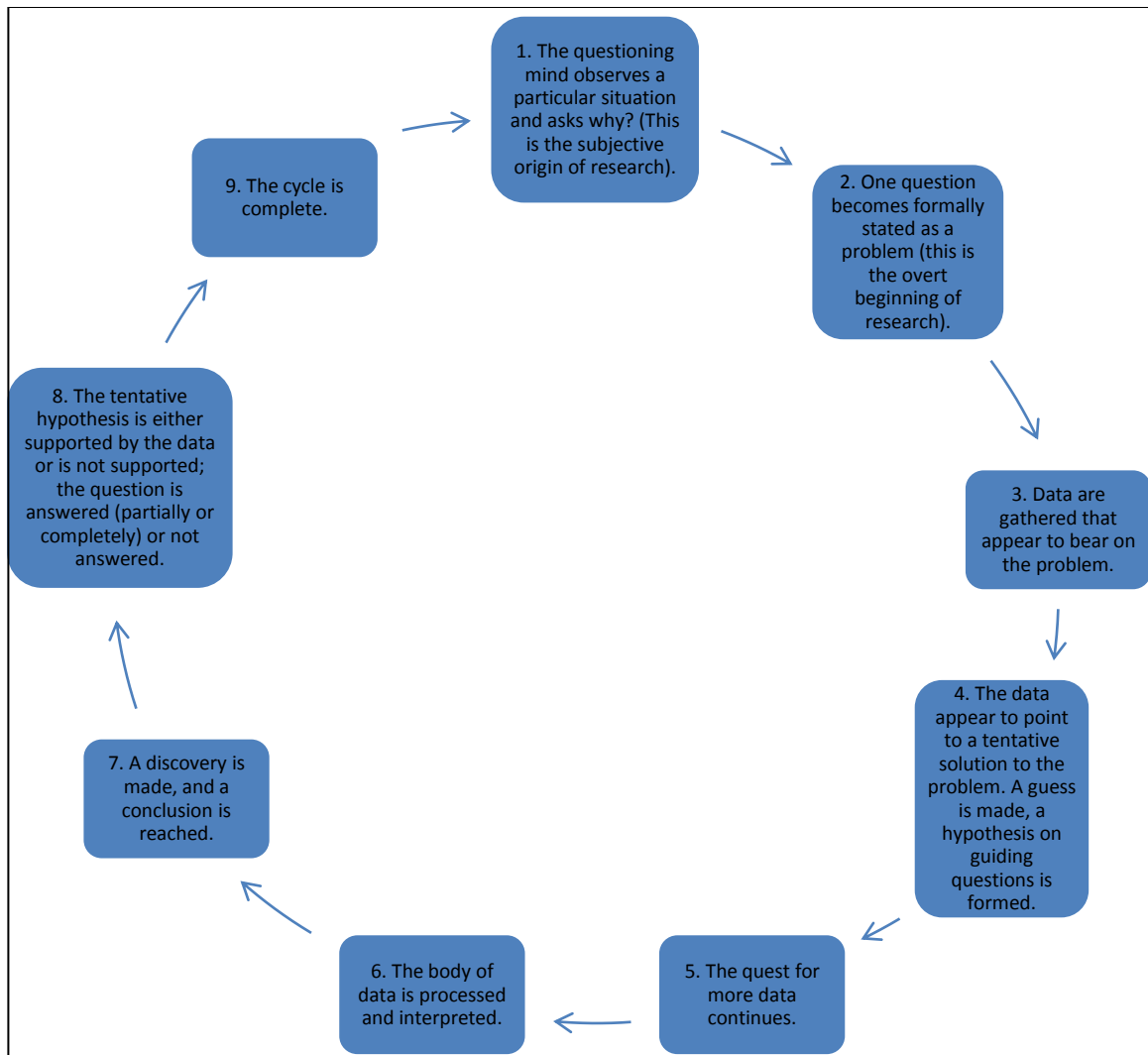


Figure 4.1 The Classical Research Cycle/ The Scientific Method (from Leedy & Ormrod, 2001)

### 4.1.3 Characteristics of Research

According to Cohen and Manion (1994, p.4) research has three characteristics, namely: systematic and controlled; empirical; and self-correcting. Similarly, McMillan and Schumacher (1989, p.8) state that research is “*a systematic process of collecting and analyzing information (data) for some purpose*”. Kerlinger (1986, p.10) defines scientific research as “*systematic, controlled, empirical and critical investigation of natural phenomena guided by theory and hypotheses about the presumed relations among such phenomena*”. In addition, Wiersma considers 5 general characteristics which apply to research and specifically educational research:

- 1) Research is empirical.
- 2) Research can take a variety of forms.
- 3) Research should be valid.
- 4) Research should be reliable.
- 5) Research should be systematic.

Each of these definitions agrees that research must be systematic. For a research study to be systematic, according to Wiersma (1991), the nature of the problem to be researched must be broadly defined. Related knowledge must be identified in a review of the literature and a framework must be established in which to conduct the research. For this thesis, we conduct a review of the related literature in Chapter 2, while the theoretical framework for this research study is outlined in Chapter 3. That research is empirical and can take many forms will be illustrated further in Section 4.2 on research methodologies. The validity and reliability of research is also discussed later in this chapter in Section 4.5.

#### **4.1.4 Research Design**

Creswell (2003, p.5) developed a framework for designing a research study based on elements of inquiry, approaches to research and design processes of research and this framework is described in Table 4.1. The research design adopted for this research study ties in with Creswell's framework.

<b>Elements of Inquiry</b>	<b>Approaches to Research</b>	<b>Design Processes of Research</b>
<ul style="list-style-type: none"> <li>• Alternative Knowledge Claims</li> <li>• Strategies of Inquiry</li> <li>• Methods</li> </ul>	<ul style="list-style-type: none"> <li>• Qualitative</li> <li>• Quantitative</li> <li>• Mixed Methods</li> </ul>	<ul style="list-style-type: none"> <li>• Questions</li> <li>• Theoretical Lens</li> <li>• Data Collection</li> <li>• Data Analysis</li> <li>• Write-up</li> <li>• Validation</li> </ul>

**Table 4.1: Knowledge claims, strategies of inquiry and methods leading to approaches and the design process (Creswell, 2003)**

In order to investigate post-primary students' images of mathematics in Ireland we employ a combination of research methods under a mixed-methods approach. As such the research design of this study is outlined as follows:

1. **Original research question:** What is the image of mathematics held by post-primary students in Ireland?
2. **Research goal:** To discover the image of mathematics held by 5<sup>th</sup>-year post-primary students studying ordinary level mathematics.
3. **Stage One – Element of Inquiry:** A review of the related literature was carried out in order to discover how previous research had dealt with this issue and to discover possible methods for carrying out this research study – Chapter 2.
4. **Stage Two – Research Questions:** Following a review of the relevant literature, the original research question was divided into a number of sub-questions in order to examine the research problem in more depth – Chapter 2.
5. **Stage Three – Theoretical Framework:** A theoretical framework was developed for the research study based on the literature review and in order to address the research questions – Chapter 3.
6. **Stage Four – Element of Inquiry and Approach to Research:** The method of data collection is chosen – a postal survey, and the test instrument is

developed – a questionnaire designed to examine students’ images of mathematics. The methodology for the study is selected based on a ‘mixed-methods’ approach, combining both qualitative and quantitative research, using both qualitative and quantitative questions – Chapter 4.

7. **Stage Five – Pilot Study:** A pilot study was carried out in order to assess the test instrument prior to the main data collection stage. Minor changes are made to the questionnaire – Chapter 5.
8. **Stage Six – Data Collection:** A sampling methodology is developed and a sample of 5<sup>th</sup>-year post-primary students is chosen and approached to take part in the study. Data is collected from students using the amended questionnaire.
9. **Stage Seven – Data Analysis:** Data collected from students is analysed using SPSS and findings are discussed – Chapters 6 & 7.
10. **Stage Nine – Write-up:** Interpretation of data and findings are discussed together with conclusions and recommendations – Chapters 8 & 9.

## ***4.2 Methodology – A Mixed-methods Approach***

The aim of methodology is to help us to understand the process of scientific enquiry not the products (Kaplan, 1973). The purpose of the research methodology is to effectively acquire and interpret the data necessary for the research project, thus leading to the enhancement of the state of knowledge. In this section we examine qualitative and quantitative research paradigms. This section looks at the advantages and disadvantages in choosing a particular research methodology and we also discuss the methodology selected for this research study – a mixed-methods approach.

### **4.2.1 Qualitative or Quantitative?**

Traditionally, methodology paradigms were divided strictly into two distinct categories: the quantitative paradigm and the qualitative paradigm. The debate regarding the merits of each of these methods became known as ‘the great paradigm wars’ or ‘the paradigm problem’. The quantitative paradigm is also described as traditional, conventional, scientific, experimental, positivist, empiricist and

hypothetico-deductive. The qualitative paradigm is also known as naturalistic, constructivist, interpretivist, post-positivist, holistic-inductive and alternative (Clarke, 1999).

The quantitative and qualitative paradigms are divided specifically in terms of their ontology, epistemology and methodology. Ontology is concerned with the nature of the phenomenon being investigated. Epistemology relates to knowledge, its nature and forms, how it can be acquired and how it can be communicated to others. Methodology deals with the particular ways of knowing reality. Cohen and Manion (1997) suggest a fourth assumption concerning human nature and the relationship between human beings and their environment which also divides the two paradigms.

### **Quantitative:**

The ontological assumption under a quantitative paradigm is that social reality is external for individuals, imposing itself on their consciousness from without and is therefore objective (Cohen and Manion, 1997). Epistemologically, the researcher is independent from his or her research subject and does not influence nor is influenced by the object of the study. As such, knowledge is identified as being hard, real and capable of being transmitted in a tangible form. With regards to the methodology, the quantitative paradigm follows rational methods of inquiry to discover relationships between variables and to analyse social, educational and other phenomena. Finally, for the quantitative paradigm, human beings are seen as responding mechanically to their environment.

### **Qualitative:**

In contrast, the qualitative paradigm is based on the ontological belief that there are many different 'Truths' depending on one's construction of reality. Reality is seen to be the product of human consciousness and is therefore the result of individual cognition. Consequently reality is subjective rather than objective in nature. This paradigm rejects the idea of a single objective reality but rather, it maintains the epistemology that there are multiple subjective realities, that the



researcher is not independent of his or her research subject. Knowledge is identified as softer, subjective or even transcendental, based on experience and insight of a unique and personal nature (Cohen and Manion, 1997). Methodologically, the qualitative paradigm focuses on the process and meanings of phenomena (Lincoln & Guba, 2000). Finally, for a qualitative paradigm, an image of human beings emerges that portrays them as initiators of their own actions.

#### **4.2.2 Qualitative and Quantitative Paradigms in Educational Research**

We have seen that quantitative and qualitative research have their own characteristics, but as applied to educational research, the distinction is more on a continuum than a dichotomy, according to Wiersma (1991). For Wiersma, the purpose of qualitative research is to understand social phenomena while the purpose of quantitative research is to determine relationships, effects and causes. Both the quantitative and qualitative paradigms are used in educational research. Although supporters of each paradigm were once divided on their respective advantages and disadvantages, a new culture of mixed-methods research has begun to emerge combining quantitative and qualitative methods. Through this mixed-methods approach, researchers can take advantage of the strengths in each paradigm in order to achieve well-rounded research. In spite of the obvious ontological, epistemological and methodological differences between the quantitative and qualitative paradigms, there are also similarities between the two as outlined by Sechrest and Sidana (1995, p.78). These similarities include:

- The ultimate goal of understanding the world in which we live.
- The use of empirical observations to tackle research questions.
- Data is described.
- Explanatory arguments are constructed.
- Precaution is taken to minimise bias and other sources of invalidity.

This research study incorporates both qualitative and quantitative research purposes, as it attempts to understand the image of mathematics held by students in

Irish post-primary schools as well as determine relationships between variables which may affect students' images of mathematics. Therefore a mixed-methods approach has been adopted for this study.

#### 4.2.3 A Mixed-Methods Approach

Johnson & Onwuegbuzie (2004, p. 17) define mixed-methods research as *“the class of research where the researcher mixes or combines quantitative and qualitative research techniques, methods, approaches, concepts or language into a single study”*. As stated in the previous section, Section 4.2.2, mixed-methods had received increasing attention from researchers in recent years. Researchers gain several advantages by adopting a mixed-methods approach to research. Bryman (2006) proposed a scheme for justifying the use of the mixed-methods approach in educational research. The justifications are as follows:

- **Triangulation/Greater validity:** “Quantitative and qualitative research might be combined to triangulate findings in order that they may be mutually corroborated”.
- **Offset:** “Combining them (qualitative and quantitative) allows the researcher to offset their weaknesses to draw on the strengths of both”.
- **Completeness:** “The researcher can bring together a more comprehensive account of the area of enquiry in which he or she is interested if both quantitative and qualitative researches are employed”.
- **Process:** “Quantitative research provides an account of structures in social life but qualitative research provides sense of process”.
- **Different Research Questions:** “Quantitative and qualitative research can each answer different research questions”.
- **Explanation:** “One is used to help explain findings generated by the other”.
- **Unexpected Results:** “That quantitative and qualitative research can be fruitfully combined when one generates surprising results that can be understood by employing the other”.

- ***Instrument Development:*** “Context in which qualitative research is employed to develop questionnaire and scale items”.
- ***Sampling:*** “Refers to situations in which one approach is used to facilitate the sampling of respondents or cases”.
- ***Credibility:*** “Refers to suggestions that employing both approaches enhances the integrity of findings”.
- ***Context:*** “The combination is rationalized in terms of qualitative research providing contextual understanding coupled with either generalizable, externally valid findings or broad relationships among variables uncovered through a survey.
- ***Illustration:*** “The use of qualitative data to illustrate quantitative findings”.
- ***Utility:*** “Combining the two approaches will be more useful to practitioners and others”.
- ***Confirm and Discover:*** “Using qualitative data to generate hypotheses and using quantitative research to test them with a single project”.
- ***Diversity of Views:*** “Combining researchers’ and participants’ perspectives through quantitative and qualitative research respectively, and uncovering relationships between variables through quantitative research while also revealing meaning among research participants through qualitative research”.
- ***Enhancement:*** “Augmenting either quantitative or qualitative findings by gathering data using a qualitative or quantitative research approach”.

For this research study, a mixed-methods approach is evident in and justified by the use of methodological triangulation. Denzin (1970) identifies two categories of methodological triangulation, ‘within methods’ triangulation and ‘between methods’ triangulation. Triangulation ‘within methods’ concerns the replication of a study as a check on reliability and theory confirmation according to Cohen & Manion (1997). On the other hand triangulation ‘between methods’ involves the use of more than one method in the pursuit of a given objective. One of the main advantages of using triangulation in a research study is that it allows the researcher to have greater confidence in the research findings than is the case when a single method is used. The

use of mixed methods reduces the risk of measurement error and helps to overcome problems of bias (Clarke, 1999). Mixed methods employed for this research study are outlined in Table 4.2.

Stage of Research	Qualitative Data Collection	Quantitative Data Collection	Qualitative Data Analysis	Quantitative Data Analysis
Lit. Review	Yes	No	Yes	No
Pilot Study	Yes	Yes	Yes	Yes
Questionnaire	Yes	Yes	Yes	Yes

**Table 4.2: Mixed Methods Employed in This Study**

### **4.3 Methods**

Cohen et al. (2000, p.44) define methods in research as the procedures and techniques used in the collection of data. The methods employed in this research study are discussed in this section. The research methods used include a literature review and a questionnaire survey.

#### **4.3.1 Literature Review**

When reviewing the literature, a researcher attempts to determine what others have learned about similar research problems and to gather information relevant to the research problem at hand (Wiersma, 1991). It was clear from the beginning of this research study that there had been little or no research carried out regarding Irish post-primary students' images of mathematics. Therefore it was necessary to examine the literature dealing with similar issues, both in Ireland and internationally. This literature was sourced from books in the libraries at UCC and UL as well as inter-library loans from some other universities. Online journals also provided a significant amount of literature, either through the UCC library or the internet. Some relevant

PhD theses were also obtained from their authors, from the UL library or via the internet.

In our literature review, studies dealing with images of mathematics as well as related topics were examined leading to the theoretical understanding of 'image of mathematics' adopted in our thesis (see Section 3.3). As our conceptual understanding of image of mathematics developed, we decided that it was also necessary to consider literature examining the elements that were included in the consensual understanding of image of mathematics among researchers. These elements were identified as attitudes, beliefs, emotions, self-concept, and past experiences regarding mathematics. Due to the vast quantity of research which has been carried out on both a national and international level on some of these elements such as attitudes to mathematics and beliefs about mathematics, a thorough review of the literature regarding each of the elements was beyond the scope of this thesis. Nevertheless, the research studies that were considered in the review did introduce several lines of enquiry into our study – for example gender issues and achievement in mathematic. A number of new research questions now appeared relevant to our study; see Section 3.6. The literature review also informed the theoretical framework chosen in this thesis regarding attitudes, emotions, self-concept, beliefs and motivation in mathematics (see Section 3.4).

Our review of the research literature aided the development of a theoretical framework for this research study and this in turn directed the methodological stance of the study. It was by reviewing previous research studies that we decided on the methods of data collection to be used for our own study. A questionnaire survey was identified as the most suitable method for our research purpose. The method of data collection is outlined in Section 4.3.2.

#### **4.3.2 Questionnaire Survey**

As mentioned in the previous section, a questionnaire survey emerged from the literature review as the most promising method of data collection for this research study. According to Wiersma (1991, p.16), survey research deals with the incidence,

distribution, and relationship of educational, psychological, and sociological variables.

There are two general types of items used for questionnaires namely, 1) selected response or fixed-choice items for which the respondent selects from two or more options and 2) open-ended items for which the respondent constructs a response. There are advantages and disadvantages of both types of items (Wiersma, 1991).

#### **Fixed-choice Items:**

- *Advantage* – They enhance consistency of response.
- *Advantage* – Data tabulation generally is straightforward and less time-consuming.
- *Disadvantage* – Possibility of ‘boxing-in’ the respondent in the breadth of the response.

#### **Open-ended Items:**

- *Advantage* – There is more freedom of response because certain feelings or information may be revealed that would not be forthcoming with fixed-choice items.
- *Disadvantage* – Responses tend to be inconsistent in length, and sometimes in content, across respondents.
- *Disadvantage* – Questions and responses are susceptible to misinterpretation.
- *Disadvantage* – Data can be more difficult to tabulate and synthesize.

Bearing in mind the research questions for this study and taking into account the advantages and disadvantages of the two types of questionnaire items; we chose to use a combination of both the quantitative fixed-choice items and the qualitative open-ended items. The majority of the items would be of the fixed-choice format in order to facilitate data tabulation and analysis as well as consistency of response. A small number of open-ended questions would be used to gain more information from

students, in particular with regard to areas which could not easily be worded as a fixed-choice item, i.e., questions relating to students' own experiences of mathematics. A copy of the questionnaire is attached in Appendix A.

#### **4.3.2.1 Fixed-Response Items**

From the theoretical framework which we adopted in this study, it was clear that we needed a method which could accurately and reliably examine each of the elements comprised in our understanding of image of mathematics. The theoretical framework for image of mathematics, see Figure 3.2 in Chapter 3, incorporates three distinct domains: the affective, the cognitive, and the conative. Furthermore, five elements are included in these domains:

- Attitudes – Affective
- Emotions – Affective
- Self-concept – Affective
- Beliefs – Cognitive
- Motivation – Conative.

As our construct of 'image of mathematics' had not been examined by any previous research study, we therefore looked to the five elements above, when composing our questionnaire. From the literature, it was evident that a number of scales had been developed to examine attitudes, emotions, self-concept, beliefs and motivation and these scales had been used extensively and effectively in similar research studies. Thus, it was decided to select appropriate scales to examine each of the five aspects of image of mathematics. These scales were made up of fixed-choice items, contributing to the quantitative part of our questionnaire.

#### **Attitude towards Mathematics:**

Aiken's 1974 Enjoyment of Mathematics (E) Scale and Value of Mathematics (V) Scale were chosen for this study because they measure aspects of attitude which fall within our theoretical understanding of attitude. Aiken constructed the Enjoyment

scale as a measure of the enjoyment of mathematics; it was found to be highly related to measures of mathematical ability and interest (Aiken, 1974, p.70). The Value scale was constructed to measure the “recognized importance” or value of mathematics to the individual and society (Aiken, 1974, p.67). These scales have proved to be a reliable measure for attitudes toward mathematics and so were chosen for our study.

In addition to Aiken’s 1974 scales, we also examined the Fennema-Sherman 1976 Mathematics Attitude Scales which are made up of nine Likert-type scales that measure various aspects of attitude. Some of these scales overlapped with Aiken’s, while others did not lie within our definition of attitude for this study. However, one of the Fennema-Sherman scales was deemed appropriate for our study, namely the ‘Attitude Toward Success in Mathematics (AS)’ Scale. According to Fennema & Sherman (1976, p.3), the Attitude toward Success scale was designed to measure the degree to which students anticipate positive or negative consequences as a result of success in mathematics. Each of the nine Fennema-Sherman scales can be used individually or as a group while remaining a reliable measure of attitude (see Fennema & Sherman, 1976; Pedro et al., 1981). Therefore, combining the three scales chosen we could now measure attitude to mathematics comprehensively in terms of:

1. Students’ enjoyment of mathematics – Enjoyment of Mathematics Scale (Aiken, 1974).
2. Students’ value of mathematics - Value of Mathematics Scale (Aiken, 1974).
3. Students’ attitude toward success in mathematics – Attitude Toward Success in Mathematics Scale (Fennema & Sherman, 1976).

### **Emotions about Mathematics:**

As discussed in the literature review Section 2.5, the most commonly talked about emotion with regards to mathematics education research is that of anxiety. Anxiety about mathematics is a strong feature of research in mathematics education in recent years. Scales specifically designed to measure anxiety about mathematics have been developed such as the Mathematics Anxiety Rating Scale (MARS) (see



Clute, 1984; Ferguson, 1986). However bearing in mind the length of our questionnaire, we looked for a more concise scale which would not only fit into our questionnaire in terms of length and layout, but would nevertheless effectively examine emotions/anxiety about mathematics. We chose to use the 12-item Fennema-Sherman 1976 Anxiety about Mathematics (A) Scale. This scale is not intended to measure confidence in or enjoyment of mathematics but rather to measure feelings of “anxiety, dread, nervousness and associated bodily symptoms related to mathematics” (Fennema & Sherman, 1976), and therefore the Anxiety about Mathematics Scale was deemed an appropriate scale to measure our understanding of emotions about mathematics.

### **Self-concept in Mathematics:**

Similarly to anxiety about mathematics, self-concept in mathematics has emerged in recent years as one of the major concerns in mathematics education research. Beliefs about one’s ability to perform well in mathematics can play a significant role in not only performance in mathematics but also in choosing to study mathematics. For this study, Gourgey’s 1982 Mathematical Self-concept scale was chosen to measure self-concept in mathematics as this scale reflected the theoretical understanding of mathematical self-concept adopted for this study. Gourgey’s purpose in developing her Mathematical Self-concept scale was to create a valid and reliable measure of mathematical self-concept which would assess students’ attitudes, beliefs and feelings towards their own ability to understand and perform in mathematics. Bearing in mind the overall length of our questionnaire, we opted to use a 12-item subset of Gourgey’s original 27-item scale as supported by Miller-Reilly (2005) and Liston (2009). Miller-Reilly found high correlation (0.94) between this 12-item subset and the original 27 items, indicating its reliability as a substitute for the full length Mathematical Self-concept scale.

**Beliefs about Mathematics:**

To examine beliefs regarding mathematics, Schoenfeld's 1989 Beliefs about Mathematics Scale was chosen because of Schoenfeld's influential position in the area of belief research – this is supported by McLeod (1994). As this research project is concerned with students' beliefs about mathematics, only Section 7 of Schoenfeld's original scale was used. This is supported by Miller-Reilly (2005) and Wood & Smith (1993) who found that the six items in Section 7 were sufficient to investigate students' beliefs about mathematics.

A recurring theme in the literature on beliefs about mathematics is gender differences in mathematics (see Forgasz, 1995; Leder, 2007; Pálsdóttir, 2007). Although gender differences in mathematics are no longer as significant as in previous years, we thought it sufficiently important to incorporate this aspect of beliefs into our study. As such, Fennema-Sherman's 1976 Mathematics as a Male Domain (MD) Scale is used to investigate beliefs about gender differences in mathematics. Combining Schoenfeld's Beliefs about Mathematics Scale and the Fennema-Sherman Mathematics as a Male Domain scale, we can gain an insight into students' mathematical beliefs in terms of general beliefs about the subject of mathematics, stereotypical beliefs about mathematics and gender beliefs in mathematics.

**Motivation in Mathematics:**

Motivation in mathematics has not received the same amount of attention by researchers as the other elements in our understanding of image of mathematics as mentioned in Section 3.4.3. It was previously considered as an attitude dimension or part of the beliefs spectrum but for this study we examine motivation as a concept. Based on the definition of motivation adopted in this study, we chose to use Fennema & Sherman's 1976 Effectance Motivation in Mathematics Scale. Although originally designed to measure an aspect of attitude, the purpose of the scale still ties in with our conceptual understanding of motivation as it aims to measure students' "Effectance"

in mathematics with motivation ranging from students' lack of involvement in mathematics to their active enjoyment of mathematics and seeking of challenge.

In total, 8 scales were selected to examine image of mathematics in terms of attitudes, emotions, self-concept, beliefs and motivation regarding mathematics. These eight Likert-type scales were composed of 87 items in total with each item holding 5 fixed responses of Strongly Disagree, Disagree, Unsure, Agree and Strongly Agree. Students would tick the box corresponding to the response they felt applied to them for each of the 87 items. Each of the 8 scales used consisted of both positively and negatively worded items. For the purpose of the questionnaire and to ensure students could not detect any patterns when responding to items, it was decided that the 87 items would appear in a random order in the questionnaire. It was also necessary to consider the language of the items, that they would be understandable for 5<sup>th</sup>-year students in Ireland. As each of the scales selected had been developed in a country where English was also the first language, there was no problem regarding translation. However, of concern was the fact that some of these scales had been developed over 30 years ago and therefore the readability of items may not be entirely suited to our young audience. Therefore, a small number of minor changes were made to the wording of items, for example words that were not easily recognisable to 5<sup>th</sup>-year students were replaced with more familiar terms of the same meaning. Any changes made did not change the meaning of the items and were only intended as a means of clarifying any possible difficulties in understanding items.

### **Analysis of Likert Scales**

The analysis of the quantitative data – Chapter 6 – depends largely on the analysis of the 8 Likert scales aforementioned. There has been some debate among researchers regarding the analysis of Likert scales: see Jamieson (2004); Cohen et al. (2000); Blaikie (2003); Knapp (1990). This debate is concerned with the treatment of Likert scales as interval scales (intervals between values presumed to be equal) or ordinal scales (intervals between values not presumed to be equal). For some researchers, Likert scales measuring attitudes or beliefs etc are viewed as ordinal

scales with methodological and statistical implications. For example, calculating the mean and standard deviation for ordinal scales is deemed inappropriate and instead, researchers should employ the median or mode and analysis of data should involve non-parametric tests. On the other hand, it has become common practice to assume that Likert-type categories constitute interval-level measurement (Jamieson, 2004). In the analysis of Likert scales, Knapp suggests that sample size and distribution are more important than level of measurement in determining whether it is appropriate to parametric statistics. Thus, there appears to be a continuing debate regarding the analysis of Likert scales. In the analysis of our quantitative data, we employ both parametric and non-parametric statistical tests carrying out the required checks for testing the appropriateness of the data for each statistical technique used.

#### **4.3.2.2 Open-ended Questions**

The bulk of the questionnaire is made up of the fixed-choice items from the 8 scales discussed in Section 4.3.2.1. As stated, these fixed-choice items will examine students' attitudes, emotions, self-concept, beliefs and motivation with regards to mathematics. Although these elements form the major part of our definition of 'image of mathematics' for this study, they do not account for our understanding of image of mathematics completely. In Section 3.3 of this thesis, image of mathematics is conceptualized as: *A mental representation or view of mathematics, presumably constructed as a result of past experiences, mediated through school, parents, peers or society.* The affective, cognitive and conative aspects of 'image of mathematics' are addressed in the fixed-choice section of our questionnaire but there are no scales to examine students' past experiences of mathematics or the factors influencing their image of mathematics. As these two elements of our definition are entirely subjective and personal to each individual, open-ended questions were deemed the best means of obtaining information regarding students' experiences of mathematics and the factors influencing their images of mathematics.

As well as examining the past experiences and factors of influence based on our definition of mathematics, the open-ended questions were also used to investigate students' causal attributions for success or failure in mathematics.

In an attempt to gain a clearer insight into the image of mathematics of 5<sup>th</sup>-year post-primary students in Ireland, it was decided to draft 5 open-ended questions for the questionnaire that would examine past experiences, factors of influence and causal attributions of students. The number of open-ended questions is much smaller than the number of fixed-choice items in the questionnaire for 1) practical reasons (the time required to tabulate and analyse responses), and 2) bearing in mind the length of the overall questionnaire and the time required by students to complete the questionnaire.

#### **4.3.2.3 Questionnaire Construction**

Based on the questions devised to examine 5<sup>th</sup>-year post-primary students' images of mathematics, the layout of the questionnaire was divided into three sections. The first section of the questionnaire, the Student Profile section, would ask students to provide some basic background information. This section was kept as minimal as possible and only questions that might be useful in establishing a deeper understanding of students' images of mathematics were included in this section. Students were advised that none of these questions were compulsory (apart from "name of student" which was necessary to determine if students had signed the Informed Consent forms – this will be discussed in Section 4.6 on Ethics).

The next section of the questionnaire consists of the open-ended questions discussed in Section 4.3.2.2. It was decided to put the open-ended questions ahead of the fixed-choice items as there are fewer to answer and as students may give more information on these at the beginning of the questionnaire rather than the end when they may have grown tired of the questions. As the open-ended questions signal the beginning of the actual survey, this section was headed Section A. Students were requested to answer all questions as honestly and in as much detail as possible. Four of the five open-ended questions contained two parts with the first part consisting of a

“tick the box” option. The purpose of this tick the box option was to, in part, clarify questions which may otherwise be misunderstood by students and direct responses in a particular direction, and in addition, to provide a means of analysing parts of the questions more quickly and efficiently on SPSS.

The final section of the questionnaire was made up of the 87 items from the 8 scales chosen in Section 4.3.2.1. This section – Section B – held the most questions and therefore constituted the main part of the questionnaire. As mentioned in Section 4.3.2.1, the 87 items were jumbled up in order to prevent students from identifying patterns in the items and responding mechanically rather than honestly.

According to Wiersma (1991), before preparing the final form of the questionnaire, the items should be tried out with a small group in a pilot run. He adds that by piloting the questionnaire, deficiencies may be uncovered that were not apparent by simply reviewing the items. According to Wilson & McLean (1994, p.7), there are several functions of a pilot study, *“principally to increase the reliability, validity and practicability of the questionnaire”*. Therefore it was decided to conduct a pilot study prior to the main data collection stage to identify any possible deficiencies in the questionnaire. As the main purpose of the pilot study was to test the questionnaire and not the students specifically, a small sample of first and second year university students were asked to complete the questionnaire. The pilot study findings and outcomes are discussed in Chapter 5 of this thesis.

#### **4.3.2.4 Questionnaire Distribution**

Following the piloting of the questionnaire, a final version of the questionnaire was composed. The next stage was to select a sample of 5<sup>th</sup>-year post-primary students studying ordinary level mathematics. In this section we discuss the sampling of students, contacting schools and participants for the survey and distribution of the questionnaire.

### **Sampling:**

Due to factors of expense, time and accessibility, it is not always possible or practical to obtain measures from a population (Cohen & Manion, 1997, p.87). Thus, researchers endeavour to collect information from a smaller group or subset of the population in such a way that the knowledge gained is representative of the total population under study. This smaller group is a sample. Cohen et al. (2000) describe the two main methods of sampling as a probability and a non-probability sample. Leedy & Ormrod (2001) explain that for a non-probability sample, the researcher does not guarantee that each element of the population will be represented in the sample. For a probability sample, the researcher can specify that each segment of the population will be represented in the sample. The method of sampling adopted for this study is probability sampling. As previously stated, no prior research study has examined the image of mathematics of post-primary students in Ireland. However, the Economic and Social Research Institute (ESRI) has conducted a study *Growing Up in Ireland* in which a representative random sample of nine-year-olds were selected. For our research study, we adopt a sampling methodology similar to this ESRI study – see Murray et al. (2011). The sampling methodology for our study is detailed in Section 4.4.

### **Contacting Schools:**

Prior to contacting schools and students to ask for their participation in our study, we obtained ethical permission from the Ethics Committee at University College Cork. This is discussed further in Section 4.6. Ethical permission was particularly important in this study as the participants were under 18 years of age. Once the study had received ethical approval, a cover letter was sent to the principal of each of the 60 schools selected under our representative random sampling – see Section 4.4. The cover letter is an essential part of any survey involving a questionnaire according to Wiersma (1991, p.178). The purpose of the cover letter is to introduce individuals to the questionnaire and to motivate them to respond. Wiersma states that the letter should be straightforward, explaining the purpose and

potential value of the survey and transmitting the message that an individual's response is important. A copy of the cover letter is attached – see Appendix B.

Follow-ups are considered necessary for questionnaire surveys and they should be planned for in advance (Wiersma, 1991, p.183). Hudson & Miller (1997) suggest several strategies for maximising the response rate for postal questionnaires. These include:

- Multiple rounds of follow-up to request returns
- Including stamped addressed envelopes when sending the questionnaires
- Stressing the importance and benefits of the questionnaire

Each of these strategies was employed for this study. The cover letters were followed-up with a phone call after a week or two. If we could not speak to the principal, we continued to phone the school until contact was made. Despite our best efforts, some schools refused to participate for various reasons. All schools that agreed to participate were immediately sent 20 Informed Consent forms for students, along with instructions on randomly selecting 20 students to complete the questionnaire. A stamped addressed envelope was included at this stage as well as when the questionnaires were sent. The forms were either sent to the principal or to a mathematics teacher at the school who had agreed to assist with the survey. Schools were asked to obtain consent from students and send the forms back to us prior to distribution of the questionnaires. This was to ensure that all students who completed the questionnaires had given their consent and obtained that of their parent/guardian. In a small number of cases, some principals/teachers requested that the questionnaires be sent together with the Informed Consent forms with the assurance that no student would be allowed to complete the questionnaire without first completing the consent form.

The process of returning the consent forms and questionnaires proved to be lengthy and problematic in some cases. The principal or mathematics teacher who was assisting with the study was contacted regularly by either phone or email to offer



support and assistance should any problems arise as well as reminding schools to return items as soon as possible. Despite our best efforts to obtain 400 questionnaires, we were only able to obtain 356. This was due to a number of reasons including:

- Non-participation of schools for a variety of reasons.
- Some schools had less than 20 students studying ordinary level mathematics in 5<sup>th</sup> year and therefore less than 20 questionnaires were returned from these schools.
- Difficulty getting students to remember to return the consent forms leading to many schools returning less than 20 questionnaires.
- Difficulty getting some school contacts to return consent forms and questionnaires.
- Time constraints as there was only a limited period of time in which the data collection process could take place.
- Limited resources.

Once a school had returned the completed questionnaires, a debrief letter was sent to the school principal/mathematics teacher. The debrief letter thanked the principal/teacher for his or her assistance as well as thanking the school for participating in the survey. This letter also reminded schools about the importance and value of this research study. A copy of the debrief letter is attached in Appendix C.

#### ***4.4 Sampling Methodology***

In this study, we follow the sampling methodology used by Murray et al. (2011). The sampling objective of our research survey was to select a representative random sample of 400 5<sup>th</sup>-year ordinary level mathematics students in post-primary school in Ireland.

The first step in choosing a sample is to identify the unit of study or the sampling unit. Here the unit of study is the 5<sup>th</sup>-year post-primary student studying ordinary level mathematics. There were a total of 288,144 post-primary students

registered as attending post-primary schools in Ireland in September 2011 according to the Department of Education and Skills. The post-primary school curriculum is divided into First year, Junior Certificate cycle (2<sup>nd</sup> year and 3<sup>rd</sup> year) and Leaving Certificate cycle (5<sup>th</sup> year and 6<sup>th</sup> year) with Transition year typically offered during 4<sup>th</sup> year. For schools not offering transition year, Leaving Certificate may be classed as 4<sup>th</sup> year and 5<sup>th</sup> year. In our study, 5<sup>th</sup>-year students refer to those in their first year of the Leaving Certificate cycle (in some schools this will mean 4<sup>th</sup>-year students). In order to obtain an estimate of the number of 5<sup>th</sup>-year post-primary students in Ireland, we divide the total number of students by 6 (representing the average 6 years of post-primary school). Therefore the total number of 5<sup>th</sup>-year students is estimated at 48,024. On average, the percentage of students who take the ordinary level mathematics examination in Ireland is 72%. Although, this percentage may be lower for 5<sup>th</sup>-year students as some students drop from higher level mathematics to ordinary level in their final year of Leaving Cert, we can still reasonably estimate that 72% of the total 48024 students in 5<sup>th</sup> year are ordinary level mathematics students. Therefore approximately 34,577 post-primary students in Ireland are studying ordinary level mathematics in 5<sup>th</sup> year.

#### **4.4.1: Selecting the Sample Size**

The sample size is perhaps the single most influential element under the control of the researcher in designing the analysis of a study according to Hair et al. (2010, p.174). The effects of sample size are seen most directly in the statistical power of the significance testing and the generalizability of the result. The coefficient of determination ( $R^2$ ) is a measure of the variance of the dependent variable about its mean that is explained by the independent, or predictor variables. The higher the value of  $R^2$  the greater the explanatory power of the regression equation and the better the prediction of the dependent variable. For this study, by sampling 400 students we would detect  $R^2$  values of approximately 5% and above, 80% of the time, based on a 0.5 significance level and using between 10 and 20 independent variables. Thus the sampling aim of this study was to survey 400 students.

It is widely accepted that non-response is a major issue in surveys and particularly in postal surveys (see Wiersma, 1991). In order to achieve a sample as close to the required 400 as possible, we decided to choose a sample with three times as many students than required – 1200. Therefore, even allowing for non-response, our aim of surveying 400 students was more likely to be achieved. It was also more likely that all aspects of the population frame would be surveyed.

#### **4.4.2: Population Frame**

Following the sampling methodology used by the ESRI research group (Murray et al., 2011) in their study of nine-year olds' attitudes to mathematics; we identified the post-primary school system as a natural clustering of 5<sup>th</sup>-year post-primary students. There were 727 post-primary schools listed in Ireland for the year beginning September 2011 as listed by the Department of Education and Skills. Four of the post-primary schools on the list were newly amalgamated schools and contained no contact information so these were excluded from the total post-primary schools in our sampling population. Post-primary schools in Ireland fall into three categories as follows:

- Secondary schools
- Vocational schools
- Community and Comprehensive (C+C) schools (this school type is sometimes, but not always, formed when a secondary and vocational school amalgamate).

In addition, schools are also classified as Gaelscoileanna, fee-paying and boarding schools in the list provided by the Department of Education and Skills. These classifications may occur individually, simultaneously or not at all in any single school. For the purpose of our study, the classification of Gaelscoileanna was assumed to have an insignificant impact on students' images of mathematics. However, fee-paying schools were identified as having a possible effect on students' images of mathematics and therefore it was decided to include fee-paying schools as a distinct category of post-primary schools. Boarding schools were included in the

fee-paying schools category as clearly students attending boarding schools would also be paying fees to the schools. Thus the categories of post-primary schools identified in this study are:

- Secondary schools
- Vocational schools
- C+C schools
- Fee-paying schools.

In addition to dividing post-primary schools into the categories of secondary, vocational, C+C and fee-paying, it was decided also to group schools according to their co-educational status. The co-educational status of schools formed part of the sampling frame adopted by Murray et al. (2011) upon which the sampling frame for this study is based. Table 4.3 shows the co-educational status for each of the four categories of post-primary schools with number and percentage of schools in each grouping.

School Type	Number of Schools	Percentage of Schools
Single-sex Girls Secondary	120	16.60%
Single-sex Boys Secondary	90	12.45%
Co-Ed Secondary	108	14.94%
Single-sex Girls Vocational	2	0.28%
Single-sex Boys Vocational	0	0%
Co-Ed Vocational	247	34.16%
Single-sex Girls C+C	1	0.14%
Single-sex Boys C+C	1	0.14%
Co-Ed C+C	89	12.31%
Single-sex Girls Fee-paying	18	2.49%
Single-sex Boys Fee-paying	18	2.49%
Co-Ed Fee-paying	29	4.01%
Total	723	100.01%

**Table 4.3 Co-educational Status of Post-primary Schools**

The 12 sub-categories of post-primary schools shown in Table 4.3 provide information on the distribution of post-primary schools in Ireland according to school

type and co-educational status. The 12 sub-categories also indicate schools' ethos in terms of fee-paying or non-paying schools.

There are 285,872 students attending the 723 post-primary schools in our population frame. In Table 4.4 we summarize the breakdown of post-primary students according to the characteristics of the schools with regards to school type (secondary, vocational, C+C), school ethos (fee-paying) and co-educational status (single-sex girls, single-sex boys, mixed).

School Type	Number of Students	Percentage of Students
Single-sex Girls Secondary	64458	22.55%
Single-sex Boys Secondary	44694	15.63%
Co-Ed Secondary	47099	16.48%
Single-sex Girls Vocational	538	0.19%
Single-sex Boys Vocational	0	0%
Co-Ed Vocational	43452	15.20%
Single-sex Girls C+C	741	0.26%
Single-sex Boys C+C	569	0.26%
Co-Ed C+C	52943	18.52%
Single-sex Girls Fee-paying	8492	2.97%
Single-sex Boys Fee-paying	9037	3.16%
Co-Ed Fee-paying	13849	4.84%
Total	285872	100.06%

**Table 4.4 Distribution of Post-primary Students in Post-primary School Categories**

#### **4.4.3: Level of Coverage**

In using any sampling frame, it is important that it should be as comprehensive as possible with, ideally, no exclusions (Murray et al., 2011). The sampling frame chosen for this study identifies post-primary schools as the natural source of post-primary students (including our specific population aim of 5<sup>th</sup>-years). As our sampling frame includes all post-primary schools in Ireland, except for the 4 new schools without contact details aforementioned in Section 4.4.2, our sampling frame is as comprehensive as possible for this study.

#### 4.4.4: Sample Design

Similarly to Murray et al. (2011), the sample for the main data collection stage of this research study was selected on a two-staged clustered basis. A set of Primary Sampling Units (PMUs) was selected. The PMUs were the post-primary schools in Ireland. 5<sup>th</sup>-year post-primary students are naturally clustered into the post-primary school system. Prior to selection, schools were stratified according to:

- **Type of Post-primary School:** Secondary schools, Vocational Schools, C+C schools
- **School Ethos:** Fee-paying, Non Fee-paying (i.e., All schools outside of the fee-paying category)
- **Co-educational Status:** Single-sex Girls, Single-sex Boys, Co-Educational.

All post-primary schools were included as listed by the Department of Education and Skills aside from the four newly amalgamated schools without contact details as mentioned earlier. A random sample of 60 schools was initially selected on a stratified systematic basis. For the 60 schools selected for the sample, similarly to the ESRI study (Murray et al., 2011), a maximum threshold of 20 students was set in any one school. The threshold was chosen for a number of reasons as follows:

- Within-school variability of student characteristics will be less than between-school variability. Thus to enhance the independence of our unit of study (i.e., students), we decided on a maximum of 20 students per school.
- Due to time and resource constraints the maximum number of schools we could reasonably include in the study was 60. In previous studies involving surveys with schools, participation by all schools can be extremely difficult to achieve and therefore we needed a balance between the number of schools participating in the study and the number of students required for the study. In the hope of achieving approximately a 50% participation rate from schools, setting a threshold of 20 students per school meant we should achieve our target of 400 students (allowing that not all schools would have 20 5<sup>th</sup>-year ordinary level mathematics students).

- 6 schools were contacted prior to choosing the maximum threshold in order to obtain some idea of the average number of students in a 5<sup>th</sup>-year ordinary level mathematics class. Responses varied between 15 and 30 students with the average being 23. This was reduced to 20 in order to facilitate statistical procedures in the sampling.
- Finally, the maximum threshold minimises the respondent burden for the principal and staff of the school involved. For large schools, if all 5<sup>th</sup>-year ordinary level mathematics students were asked to complete the survey, this could involve perhaps 100 students which would be time-consuming, laborious and would possibly lead to non-participation of schools in such instances.

Schools were provided with instructions for selecting a random sample of 20 5<sup>th</sup>-year ordinary level mathematics students. An information sheet advised schools with fewer than 20 ordinary level students that all students should be asked to participate. For schools with more than 20 students, a random digit table with instructions was provided. Of course if the number of students studying ordinary level mathematics was just one or two more than the 20 students required, some leniency would be necessary so as not to make a small minority of students feel excluded. This leniency was also expressed in Murray et al. (2011).

There are also some limitations to the study due to the sample design chosen. These limitations include:

- Sampling 20 students from a single school as it can be expected they will be similarly influenced by the school they attend, by their peers, by the school ethos etc. which can reduce the independence of the unit of study i.e. students. The influences of the school will be taken into account during analysis of the data.
- Ideally, more schools should be included in the sample (ESRI study had  $\frac{1}{6}$  of total schools). This could have an effect on the generalizability of results.

- We could not visit all the schools personally so we are relying on principal/staff to ensure that the sample of students in each school was randomly selected. We offered help with random selection by providing a random digit table with instructions for choosing a random sample of students. As we could not physically go to each school and witness the random selection we were relying on the school staff to do this in good faith.

The 60 schools to be selected based on the proportion of schools in each of the 12 subcategories outlined in the population frame are shown in Table 4.5.

School Type	Number of Schools	Percentage of Schools	Number of Students	Percentage of Students
Single-sex Girls Secondary	10	16.67%	200	16.67%
Single-sex Boys Secondary	7	11.67%	140	11.67%
Mixed Secondary	9	15%	180	15%
Single-sex Girls Fee-paying	2	3.33%	40	3.33%
Single-sex Boys Fee-paying	2	3.33%	40	3.33%
Mixed Fee-paying	2	3.33%	40	3.33%
Single-sex Girls Vocational	0	0%	0	0%
Single-sex Boys Vocational	0	0%	0	0%
Mixed Vocational	21	35.00%	420	35.00%
Single-sex Girls C+C	0	0%	0	0%
Single-sex Boys C+C	0	0%	0	0%
Mixed C+C	7	11.67%	140	11.67%
Total	60	100.00%	1200	100.00%

**Table 4.5: Selected Sample of Schools**

The list of post-primary schools from the Department of Education and Skills was divided into each of the above 12 categories and schools for each category were chosen randomly using a random number generator on Microsoft Excel. Recruitment of schools and distribution of questionnaires is discussed in Section 4.3.2.4 of this chapter.



The sample design for this study allows us to identify significant school effects on students' images of mathematics. It allows this sample to be as representative of the population as possible, taking into account the time and resource constraints on the researcher.

## **4.5 Validity and Reliability**

Validity and reliability are extremely important when considering and implementing a research study. They hold the key for determining the significance of a study, particularly in terms of the research methods employed and the data collected. Schoenfeld (in Lester, 2007) refers to validity and reliability as *"psychometric properties of an assessment"*.

### **4.5.1 Validity**

Leedy & Ormrod (2001, p.31) define the validity of a test instrument as *"the extent to which the instrument measures what it is suppose to measure"*. As previously stated, no previous research has examined the image of mathematics held by post-primary students in Ireland and therefore we looked at similar studies carried out both in Ireland and internationally to gain an insight into the best means of examining our issue. The validity of a test instrument is improved through the selection of an appropriate research methodology and the use of rigour and precision in the selection of methods, the collection of data and the analysis of findings. For this study, the use of a mixed-methods approach and methodological triangulation strengthens the validity of the research findings. The use of pre-determined scales in the questionnaire test instrument gives credence to the method of research used as these scales have already been shown to be valid measures in previous research. Validity in a research study can take a number of forms.

#### **Internal Validity:**

The purpose of internal validity is to demonstrate that the particular findings and conclusions resulting from the analysis can be supported and sustained by the data collected (Cohen et al., 2000). In the analysis of the data collected for this study,

we looked at the analysis performed by the original authors of the scales used in the main test instrument and followed any recommended guidelines. For internal validity, Wiersma (1991) refers to the extent to which results can be accurately interpreted. Findings from the main data collection stage were validated through the use of a variety of statistical techniques and the comparison of findings with previous similar research studies.

### **External Validity:**

According to Cohen et al. (2000), external validity deals with the degree to which the results obtained can be generalized to the broader population. One of the most influential factors on the generalizability of results/findings from a research study is the sample selected – see Hair et al. (2010). The sampling methodology adopted in this research study was adapted from the sampling methodology of the well-established and well-reputed ESRI group. Our sample size aimed to provide statistically significant results. The characteristics of the population were reflected in the sample selected in terms of the types of post-primary school attended, the co-educational status of schools and the ethos of schools in terms of fee-paying/non-fee-paying. Findings from this research study take into account the characteristics of and possible influences on students with regards to the post-primary school attended.

### **Content Validity:**

For content validity, it must be demonstrated that the test instrument(s) examines that which it claims to examine. The main test instrument for this research study is the questionnaire and as previously stated this is made up of a number of well-established scales by well-known authors in the field of mathematics education research. These scales have been used by a number of researchers for similar studies and have been shown to be valid measures of attitudes, self-concept, emotions, beliefs and motivation regarding mathematics. The extensive literature review prior to the construction of the test instrument ensured content validity. The test instrument was also pre-tested in the pilot study (see Chapter 5 of this thesis).

### **4.5.2 Reliability**

Leedy & Ormrod (2001, p.31) define reliability as “*the consistency with which a measuring instrument yields a certain result when the entity being measured hasn’t changed*”. As stated by Wiersma (1991, p.7), the reliability of a study refers to whether or not independent researchers can replicate the study. Thus if the same methods were employed with a different sample of participants, then similar results would be found. For a research study to be reliable, data collection, analysis, and interpretation must be consistent given the same conditions according to Wiersma (1991). For this research study, all participants of the sample were given the same test instrument to complete, the same analysis was performed for all test instruments and therefore consistency was ensured at all stage of the research. The reliability of the scales used in the test instrument was also assessed statistically by obtaining the Cronbach alpha for each of the 8 scales used, both during the pilot study and at the main data collection stage. Cronbach alpha provides an indication of the average correlation among all of the items that make up the scale, with higher values indicating greater reliability (Pallant, 2010, p.6). The pilot study showed that the scales had a high reliability for the sample used – see Chapter 5. The methodology chosen for this research study also lends reliability to the study, particularly in terms of triangulation and the use of rigour at all stages of research.

### **4.6 Ethics**

There has been a growing awareness of the moral issues implicit in the work of social researchers and of their need to meet their obligations with respect to those involved in or affected by, their investigations, according to Cohen & Manion (1997, p. 347). One dilemma encountered in educational research is that researchers must strike a balance between the demands placed on them as professional scientists in pursuit of truth and their ‘subjects’ rights and values potentially threatened by the research. In order to strike an appropriate balance in this research study, ethical approval was sought and granted by the Ethics Committee in University College Cork. The main ethical issue facing this research study was that participants were

under 18 years of age. Thus the main concern was the principle of informed consent and parental consent.

Cohen & Manion suggested the following guidelines from the Institutional Guide to DEW Policy (1971) for reasonably informed consent and these guidelines were adhered to for this study:

1. A fair explanation of the procedures to be followed and their purposes.
2. A description of the attendant discomforts and risks reasonably to be expected.
3. A description of the benefits reasonably to be expected.
4. A disclosure of appropriate alternate procedures that might be advantageous to the participants.
5. An offer to answer any inquiries concerning the procedures.
6. An instruction that the person is free to withdraw consent and to discontinue participation in the project at any time without prejudice to the participant.

The informed consent forms constructed for this study consisted of an information sheet outlining details of the study in full and all procedures for taking part in the study. Participation could be withdrawn at any time and confidentiality was ensured consistent with UCC guidelines for the storage of data. Students were required to put their names on the test instrument in order to ensure all students had signed consent forms and to ensure that students could withdraw from the study at a later stage. However each questionnaire was assigned a unique identification number for coding purposes and no individual student would be identified in the thesis. If students were willing to participate in the study, they were required to sign the informed consent form and the signature of a parent/guardian was also required prior to taking part in the study. A copy of the information sheet and informed consent form is attached in Appendix D.

## **4.7 Researcher Distance**

Goos & Galbraith (1996, p. 234) state that “*in any form of research, the significance of the data must always be judged relative to the researcher’s explicit or implicit theories and assumptions*”. It is important for any research study that the researchers acknowledge that they may bring their own personal biases, assumptions and expectations to the research. For this research study, researcher distance and objectivity is established by the acknowledgment of researcher bias and predispositions, through the use of a mixed-methods approach, and by adhering to ethical and professional guidelines in the collection and analysis of both qualitative and quantitative data.

## **4.8 Summary**

In this chapter the importance and characteristics of research are discussed. The research design of the study was outlined, based on the characteristics of research in Leedy and Ormrod (2005, p.3) and the framework of Creswell (2003). The qualitative and quantitative research paradigms were discussed. The methodology for this research study was argued with the advantages of the chosen mixed-methods approach summarized. This chapter also highlights the particular use of mixed-methods in this study with regards to qualitative and quantitative methods of research. The development of the test instrument is outlined. Based on the theoretical framework for the study, a questionnaire was constructed consisting of both fixed-choice items and open-ended items. Distribution of the questionnaires is discussed. The sampling methodology for this research study is reviewed in detail and is shown to play a significant role in the design of the study. The importance of validity and reliability in a research study is discussed in this chapter and researcher distance is acknowledged for this study.

## **Chapter Five**

### **The Pilot Study – Testing the Research Instrument**

## **Chapter Five: The Pilot Study – Testing the Research Instrument**

This chapter outlines the pilot study carried out to pre-test our main research test instrument – the questionnaire. The main purpose of the pilot study was to assess the questionnaire and to highlight any issues regarding accuracy and readability, to ensure it would be easily understood by students and to provide a preliminary analysis of scales. In this chapter we discuss how this pilot study was carried out as well as the findings which helped to inform the main data collection stage of this research study. A longer and more in-depth version of this chapter is available on the CD attached to the thesis (Appendix CD).

### ***5.1 Purpose of the Pilot Study***

It was decided that prior to the main data collection stage, the questionnaire should be tested with a small number of students, as suggested by Wiersma (1991). By doing so, we could identify any possible deficiencies or errors in the questionnaire before using it to examine the image of mathematics of 5<sup>th</sup> year students in Ireland. Therefore, a pilot study was conducted in April 2011 with twenty-one students in Mathematics courses in University College Cork.

#### **5.1.1 Sample for Pilot Study**

The sample of students in this pilot study were in either their first or second year at University College Cork. As the main aim of the pilot study was to assess the questionnaire and not the students specifically, we decided that it was not necessary to select 5<sup>th</sup>-year post-primary students to take part. This decision is also supported in Wiersma (1991) who states that the group used for the pilot study need not be a random sample of prospective respondents. However, he also cautions that members of the group should be familiar with the variables under study and should be in a position to make a valid judgement about the items. Thus, it was deemed appropriate to select a sample for the pilot study who would be reasonably close in age to 5<sup>th</sup>-year post-primary students and who would be able to identify to a certain extent with

students in the Leaving Cert course. Therefore, we decided that students in first or second year of university would be asked to complete the questionnaire. Permission was granted by the ethics committee at University College Cork in April 2011 to carry out the pilot study. Two lecturers, one teaching a first year mathematics course and the other a second year mathematics course, agreed to distribute the questionnaires among students in their classes. As students were aged 18 or over, there was no need to obtain permission from their parents (unlike in the main study). Students from the two mathematics classes were asked to volunteer to complete the questionnaire and were requested to sign an Informed Consent Form prior to completing the questionnaire. In total, 21 students agreed to take part in the pilot study. A total of 16 of these students were in the first year mathematics course and 5 students were in the second year mathematics course.

A preliminary analysis of the Student Profile section of the questionnaire was performed to establish the validity and reliability of our sample used. The analysis focused on the age of students and the Leaving Certificate mathematics level of students in our sample. The importance of the age of students in our pilot study sample analysis was to ensure that the sample of students who completed the pilot questionnaire was not vastly different, in terms of age, from the 5<sup>th</sup>-year students who will complete the questionnaire for the main study. If the difference in age is small, then we can reasonably assume that if the pilot sample can understand questionnaire items, then so too will the 5<sup>th</sup>-year students in the main sample. In this case, the difference in age is considered to be four years or less as 5<sup>th</sup>-year students are generally 16 years or older and our piloted students were seen to be, on average, 20 years or younger. The importance of the Leaving Certificate mathematics level of students in the pilot study was to ascertain if our sample of students could relate to 5<sup>th</sup>-year ordinary level mathematics students in terms of the level of mathematics studied at post-primary school. Obviously, as the pilot study sample of students had all chosen to study mathematics at university level there is potentially a significant difference between their image of mathematics and the image of mathematics of 5<sup>th</sup>-year post-primary students. This potential difference would be multiplied if all the



students in our pilot study had studied higher level mathematics for the Leaving Certificate. However, with a small majority of students having studied ordinary level Leaving Cert mathematics (52.4%), this gives some credence to the suitability of our pilot sample in testing the questionnaire.

### **5.1.2 Questionnaire for Pilot Study**

The questionnaire used for the pilot study was divided into three sections. The first section (Student Profile) required some background information from students, all of which was voluntary. This was in accordance with guidelines from the UCC ethics committee.

The next section (Section A) contained five open-ended questions. These open-ended questions aimed to assess:

- Participants' past experiences of mathematics.
- Factors influencing participants' images of mathematics.
- Participants' causal attributions for success and/or failure in mathematics.
- Participants' use of mathematics in everyday life.

It was hoped that this pilot study would identify any difficulties students may have in understanding these questions.

The final section (Section B) contained 87 fixed-response questions taken from the following scales:

- Aiken (1974) Enjoyment of Mathematics Scale.
- Aiken (1974) Value of Mathematics Scale.
- Fennema & Sherman (1976) Attitude Toward Success in Mathematics Scale.
- Fennema & Sherman (1976) Effectance Motivation in Mathematics Scale.
- Fennema & Sherman (1976) Mathematics as a Male Domain scale.
- Fennema & Sherman (1976) Anxiety about Mathematics Scale.
- Gourgey (1982) Mathematical Self-concept scale.

- Schoenfeld (1989) Beliefs about Mathematic Scale.

These scales were outlined in more detail in Chapter 4, Section 4.3.2.1. The aim of the pilot study to check the readability of questions for Irish students as these scales were first developed and tested in other countries several years ago. It was important to confirm that students in our main study would be able to understand all questions to ensure reliable and valid responses. The pilot study would also be used to obtain a preliminary reliability testing of these scales for students in Ireland.

For the pilot study, students were requested to comment on the questionnaire regarding content and format and a blank page was attached to the back of the questionnaire to allow for these comments.

For the analysis of the pilot study questionnaires, we chose to use the statistics computer program SPSS (originally Statistical Package for the Social Sciences). The version used for the pilot study was PASW Statistics 18, but will be referred to as SPSS as it is commonly known. In the following sections we outline the analysis performed at this stage of the research study.

## **5.2 Section A**

Section A of the questionnaire contained five open-ended questions. Four of the questions in Section A consist of two parts; the first part of the question involving a tick the box response while the second part requires further explanation from respondents.

The first stage of analysis of Section A was to check for any possible errors in the wording of questions and in the coding of responses. To check for any mistakes in the items or data entered, we analysed the frequency of responses. Once any errors had been identified and corrected, the next stage of analysis was to obtain descriptive statistics for each questionnaire item. The main aim of the descriptive statistics analysis was to identify any questions which students did not answer and to detect any patterns emerging in responses to these questions. If students appeared to avoid

certain questions we could explore possible reasons for this and try to rectify any misunderstanding of questions or irrelevance of questions to students. For any patterns which arise in responses to questions in this section, we can make comparisons with findings from the literature review and this will also pose the question as to whether these patterns will continue to appear in the main study. We now give a brief outline of the analysis of each question in Section A of the questionnaire. (Please refer to the Appendix CD for a more detailed version including tables of the descriptive statistics).

### **Section 5.2.1: Question 1**

The first question in Section A is “*What is your earliest memory of mathematics?*” Responses to Question 1 were reviewed and divided into five broad categories. These categories are: Primary School (the times tables / multiplication tables), Primary School (a specific type of mathematics being learned), Primary School (working with fellow students), Teacher, and Outside School.

A total of 19 students answered Question 1 regarding their earliest memory of mathematics. Two students did not answer this question. This is a relatively small minority compared to the 90.5% of piloted students who answered this question. The most popular response to Question 1 was regarding a specific type of mathematics learned at primary school. This category accounted for 36.8% of responses given, closely followed by Primary School - Times Tables, which accounted for 31.6% of responses given. Just over 10% of students cited their teacher in their earliest memory of studying mathematics.

A significant number of students (6 out of 21 sampled) referred to the times tables or the multiplication tables and learning these off by heart and having to recite them back. The frequency of this very specific response category is a signifier that students associate learning mathematics with this type of rote-learning which has been commonplace in the education system. This evidence of studying mathematics associated with rote-learning ties in with the work of De Corte et al (1996) and Wang (2005) which is discussed in the literature review Section 2.1.4. Whether this

impression of studying mathematics will be reflected in the responses given by our current 5<sup>th</sup>-year students remains to be seen, but it certainly gives credence to this question as providing an insight into Irish students' images of mathematics and their experience of studying mathematics.

### **Section 5.2.2: Question 2**

#### **Question 2(a):**

Question 2 poses the question "*Have your experiences of mathematics caused you to be interested/disinterested in mathematics?*" Part (a) of this question required a tick the box response, either yes or no. One student did not respond to this item. For the 20 students who answered this question, 16 students (76.2%) agreed that their experiences of mathematics had caused them to be interested/ disinterested in mathematics and 4 students disagreed. As most students answered Question 2(a) this suggests that students understood the question the majority felt comfortable answering.

#### **Question 2(b):**

Part (b) of Question 2 asks students to explain why their past experiences of mathematics have caused them to be interested or disinterested in mathematics, or for those students who feel that their experience of mathematics has not influenced their interest / disinterest, to explain their reasons for this. Categories for Question 2(b) are Interested (due to teacher(s)), Disinterested (due to teacher(s)), Interested (experience at school), Interested (because of own ability), Disinterested (experience at school), Interested (experiences outside school) and Other (just like mathematics – these students responded No to Q2 (a)).

As in the case of Question 1, two students did not respond to this question. The most common response given by students in the pilot study on Question 2 (b) was that their teachers had caused them to be interested in mathematics, with 31.6% of responses falling within this category. A total of 47.4% of responses, nearly half of

the students, cited teachers as encouraging their interest or disinterest in mathematics. The importance of teachers in students' experiences of mathematics can be seen and in some cases, 14.3% of sampled students, teachers related to negative experiences and had caused a disinterest in mathematics. Again there are similarities occurring, even for this small pilot sample, with previous investigations into students' experiences of mathematics and the influence of teachers. It is important that this question is also posed to our current post-primary students to discover if this is the case for more Irish students.

### **Section 5.2.3: Question 3**

#### **Question 3(a):**

Question 3 asks students "*Who influences you the most in mathematics?*" Part (a) offers 5 responses with students advised that they can choose more than one option if they so wish. All students answered this question. The most popular response to Question 3(a) was Mathematics Teacher, with over half of sampled students selecting this answer. Furthermore 19 out of the 21 students who completed the pilot questionnaire agreed that their mathematics teacher(s) had influenced them to some degree. The second most common response was Parent(s), cited by a third of the students sampled.

As all students answered Question 3(a) we can assume that this question was understood and relevant to the students in the pilot study. The responses given by students were consistent with their responses given to Question 1 and Question 2 of the questionnaire and once more showed many similarities with previous research. The overwhelming majority of 90.5% of students who stated that their Mathematics Teacher had influenced them to some degree in mathematics coincides with the findings from other studies regarding the factors that influence students in mathematics. The second most popular influence according to the sampled students was Parent(s) which follows previous research by Lim (1999) in which she found that parents were the second most common influence in forming an image of mathematics.

### **Question 3(b):**

In part (b) of Question 3 we asked students why they were influenced by the person/people they named in (a). Seven response categories were found: Good teachers, Good teachers and family encouragement, Parent(s) good at mathematics, Teacher is the only contact with mathematics, Teacher (negative influence), Peers (competition with peers or getting help from peers) and Other.

The most common response given by students was Good Teachers with 42.9% of students stating that they had been influenced positively by a good teacher or teachers in mathematics. Only one student referred to the negative influence of a teacher. Four students referred to family encouragement in cases where they had been influenced by their parents. For 14.3% of students, the teacher was their only contact with mathematics.

In line with previous research, mathematics teachers were seen to be the greatest influence on students in this pilot study but contrary to much of the previous research, the majority of these experiences were positive. Perhaps this is due to the fact that the students from the pilot study have all chosen to study mathematics at third level education and therefore are more likely to have positive images of mathematics related to positive experiences. Responses may differ in the main study where it is, on the whole, compulsory for 5<sup>th</sup>-year post-primary students to study mathematics. The response category in relation to family encouragement was the second most popular response given by students. As found by Fennema & Sherman (1976), influence from family was mainly seen in the form of encouragement and support in mathematics. In reference to the influence of peers, one student believed that they were motivated in mathematics to perform better than their peers resulting in an element of competitiveness. The second student who responded within this category referred to peers as a source of support and help when struggling with a mathematics problem. It is not clear whether the environment of learning at third-level may have fostered these responses as group learning and support tends to be more common at college/university level (also seen in Hill, 2008). It is clear,

however, that all students from the pilot study acknowledge that they had been influenced in mathematics by one or a combination of the factors given in the questionnaire. Therefore, this gives us confidence to continue with this question in the main study.

#### **Section 5.2.4: Question 4**

##### **Question 4(a):**

In Question 4 of Section A we ask students about their causal attributions for success and/or failure in mathematics by asking students: *Which of the following contributed most to the grade you received for mathematics in the Junior Certificate?* The students were asked to choose from Mathematics Ability; Effort; Level of Difficulty of the Exam; Luck and Other. Some of the students chose more than one response and therefore we reviewed the combination of answers and coded these responses also.

All students answered Question 4(a). The most frequent response to Question 4(a) was Mathematics Ability with 42.9% of students choosing this option. The second most common response was Effort (23.8%) which was closely followed by a combination of Mathematics Ability and Effort at 19%. No student attributed their grade for mathematics in the Junior Certificate to Luck. In previous research examining causal attributions for success and failure in mathematics, females were seen to be more likely to attribute success to unstable factors such as effort or luck while males tend to attribute success to a stable factor such as ability or level of difficulty of the exam. To compare our responses from the pilot study with findings from previous research we briefly analysed Question 4(a) in terms of gender and these findings are shown in the attached Appendix CD.

##### **Question 4(b):**

Question 4(b) asked students to explain their responses given in (a) regarding the factors that contributed to the grade they received for mathematics in the Junior

Certificate. As this was an open-ended question, students' answers were reviewed and grouped into the categories Studied / Worked hard, Naturally Good at Mathematics, Junior Cert Mathematics Easy, Good Teacher(s) and Other.

One student did not answer Question 4(b). For the remaining 20 students who responded to (b), the most frequent response given was from the category Studied/Worked Hard, with 8 students (40% of responses) falling within this grouping. The second most common response category was that of Junior Cert Mathematics Easy, with 6 students agreeing that they found mathematics and the mathematics exam easy for the Junior Certificate, particularly those who studied ordinary level mathematics.

Findings show that students believed that effort played a major role in the grade they received for mathematics in the Junior Certificate. It should be noted that 3 students believed that they were naturally good at mathematics or that they had a 'maths brain'. There was some inconsistency in responses given for part (a) and (b), (the most popular response changing from ability in (a) to effort in (b)) and this highlights the importance of open-ended questions in obtaining a more in-depth understanding of students' images of mathematics.

### **Section 5.2.5: Question 5**

#### **Question 5(a):**

In Question 5(a) students were asked "*Do you use mathematics outside school and school work?*" with Yes or No options. All students answered Question 5(a) with the majority – 76.2% - agreeing that they do use mathematics outside school and school work. It is somewhat shocking that 23.8% of university students did not see the usefulness of mathematics in their daily lives. This result does not bode well for findings in the main study, although perhaps 5<sup>th</sup>-year students will be more conscious of the utility of mathematics given the current climate of emphasising everyday mathematics problems in the new Project Maths syllabus in Irish post-primary schools.



### **Question 5(b):**

In the second part of Question 5, students were asked to give examples of using mathematics outside school and school work if they had replied Yes in part (a). If students had ticked the No option in part (a) they were asked to give reasons for why they did not use mathematics outside school. Responses include: Yes – At Work, Yes – Simple, Everyday Tasks, No – Never needed, Yes – Budgeting, and Yes – Other (specific examples).

One student did not answer Question 5(b). The most popular explanations given by students for using mathematics outside school and school work were At Work – 23.8%, Simple Tasks – 14.3% and Budgeting – 14.3%. All other examples of the utility of mathematics were specific cases and therefore grouped in the category Other with 23.8% of responses falling within this group. Question 5 of Section A remains an important question for our study to obtain an insight into post-primary students' understanding of the utility of mathematics in everyday life, particularly in the current climate of mathematics education in post-primary schools in Ireland.

## **5.3 Section B**

Section B of the questionnaire consists of 87 fixed-response items taken from the scales of Aiken (1974); Fennema & Sherman (1976); Gourgey (1982); and Schoenfeld (1989) as stated in Section 5.1.2. The 87 items in Section B were taken from 8 distinct Likert-type scales by the authors mentioned. These 8 scales aim to examine students' enjoyment of mathematics, value of mathematics, attitude toward success in mathematics, motivation in mathematics, beliefs about mathematics, views on mathematics as a male domain, self-concept in mathematics and anxiety about mathematics. Each item holds 5 optional responses namely: Strongly Disagree; Disagree; Unsure; Agree; Strongly Agree. Scores on each item range from 1 to 5 with 1 being the most negative response and 5 being the most positive response. Each of the scales used comprise of both positively and negatively worded items. Therefore, to ensure that students' scores on each scale were calculated properly, coding was reversed for negatively worded items. It is important to note that all students in our

sample answered all questions in Section B. This suggests that students were able to understand scale items as expressed. As some of the phraseology had been adjusted in certain items to suit the contemporary, Irish students in our study, it was important that we had succeeded in making each question readable and relevant to our target audience.

### **Section 5.3.1: Reliability of Scales:**

A preliminary reliability test was conducted on the 8 scales used for Section B of the questionnaire. Cronbach alpha values found for each of the 8 scales is presented in Table 5.1. Ideally, the Cronbach alpha coefficient of a scale should be above .7 according to DeVellis (2003).

<b>Scale</b>	<b>Cronbach's Alpha</b>
<b>Enjoyment of Mathematics</b> (Aiken, 1974)	<b>.878</b>
<b>Value of Mathematics</b> (Aiken, 1974)	<b>.760</b>
<b>Attitude toward Success in Mathematics</b> (Fennema & Sherman, 1976)	<b>.754</b>
<b>Effectance Motivation in Mathematics</b> (Fennema & Sherman, 1976)	<b>.863</b>
<b>Mathematics as a Male Domain</b> (Fennema & Sherman, 1976)	<b>.810</b>
<b>Anxiety about Mathematics</b> (Fennema & Sherman, 1976)	<b>.883</b>
<b>Mathematical Self-Concept</b> (Gourgey, 1982)	<b>.820</b>
<b>Beliefs about Mathematics</b> (Schoenfeld, 1989)	<b>.726</b>

**Table 5.1: Cronbach Alpha Values for Section B Scales**

From Table 5.1 we observe that Cronbach alpha's for all scales in Section B of the pilot questionnaire were above .7 with this sample of students. The lowest value found was for the Beliefs about Mathematics Scale (Schoenfeld, 1989) at .726. A possible explanation for this slightly lower Cronbach alpha is that this scale consists of only 6 items and according to Pallant (2010), it can be difficult to achieve a high Cronbach alpha value for scales with less than 10 items. The preliminary reliability analysis of the 8 scales used in our questionnaire suggests each of the scales is reliable. Indeed, 5 of the 8 scales have Cronbach alpha coefficients above .8 which implies a very high internal consistency. Thus it was decided to include each of the 8 scales in our main study test instrument.

### **Section 5.3.2: Total Scores for Scales:**

The mean total scores for each of the 8 scales of Section B are presented in Table 5.2 in order to provide an indication of the positive or negative responses given by students in the pilot study. The mean total score for a scale is the mean of all students' total scores. For example, for the Enjoyment Scale, the mean total score is 44.52 out of a possible 55 and was obtained by adding each of the students' scores for the enjoyment scale and then finding the mean. The mean total score for each scale is given together with the "unsure" score for each scale. Every item in each of the 8 scales allocates 3 points to a response which is "unsure", i.e. neither positive nor negative. By comparing the mean total score of a scale to the score received if all items are "unsure", we can detect if the students' responses were positive or negative for each scale. For example, if a mean total score is greater than the "unsure" score then it will be viewed as positive to some degree. On the other hand, if the mean total score is below the "unsure" score then it can be classed as negative. Students scored positively on each of the 8 scales, with the highest mean score found for the Male Domain scale and the lowest mean score found for the Anxiety and Self-concept scales. The extended version of this chapter has more detail on these mean scores on the Appendix CD.

<b>Scale</b>	<b>Mean Total Score</b>	<b>“Unsure” Score</b>
<b>Enjoyment of Mathematics</b> Aiken (1974)	<b>44.52/55</b>	<b>33/55</b>
<b>Value of Mathematics</b> Aiken (1974)	<b>39.38/50</b>	<b>30/50</b>
<b>Attitude toward Success in Mathematics</b> Fennema & Sherman (1976)	<b>51.33/60</b>	<b>36/60</b>
<b>Effectance Motivation in Mathematics</b> Fennema & Sherman (1976)	<b>45.90/60</b>	<b>36/60</b>
<b>Mathematics as a Male Domain</b> Fennema & Sherman (1976)	<b>54.67/60</b>	<b>36/60</b>
<b>Anxiety about Mathematics</b> Fennema & Sherman (1976)	<b>42.52/60</b>	<b>36/60</b>
<b>Mathematical Self-Concept</b> Gourgey (1982)	<b>44.19/60</b>	<b>36/60</b>
<b>Beliefs about Mathematics</b> Schoenfeld (1989)	<b>21.38/30</b>	<b>18/30</b>

**Table 5.2: Mean Total Scores for Section B Scales**

The preliminary findings from the pilot questionnaire indicated that students in the sample have a mainly positive image of mathematics in terms of their attitudes, beliefs, self-concept, motivation and emotions regarding mathematics. The preliminary analysis of the 8 scales used, suggests that they are reliable for use with Irish students and that the scale items are understandable and applicable to Irish mathematics students. As the sample size for our pilot study was relatively small, further testing of the 8 scales is required in order to test reliability further and to gain a deeper insight into the use of the 8 scales collectively, and it is aimed to examine this in more detail for the main study with a larger sample of students.

## **5.4 Comments**

For the pilot study, we requested that students comment on the questionnaire in order to gauge their reactions to the intended test instrument for the main data

collection stage. Out of the 21 students who completed the pilot questionnaire, 6 students left a comment and these 6 comments are outlined below.

1. *“Lots of the questions (1-87) were quite similar.”*
2. *“Since College, I have found the maths a lot harder.”*
3. *“My answers are as I would have answered them if I was in 6<sup>th</sup> year. I wasn’t sure if you wanted my answer from now (as in 3<sup>rd</sup> level education) or in 2<sup>nd</sup> level.”*
4. *“There are no 1’s and 2’s at Junior Cert level.”*
5. *“Good questionnaire but way too many questions in Section B. Fifth years would not answer that many questions and many are repetitive. Thank you.”*
6. *“Brilliant questionnaire – thoroughly enjoyed doing it!”*

We reviewed the pilot questionnaire as a result of the statements above and, consequently, we made the following changes:

- In the Student Profile Section the question regarding the grade received for the Junior Certificate was altered. For example, instead of A1, A2, B1, B2, B3 etc., we now use A, B, C, etc.
- In Section B, following concerns that the questionnaire was repetitive and too long, each of the items were reviewed and any repetition was eliminated (3 items appeared twice and these were omitted). Although one student stated that the questionnaire was too long for 5<sup>th</sup>-year students, we decided not to remove any of the other questions or the scales used in the pilot study as we could not justify doing so based on one person’s opinion.

In general, the pilot questionnaires were well received by the sample of students and the majority of questions were answered by most or all students. Feedback from the pilot questionnaire led to some minor changes to the test instrument which would improve the quality and design of the questionnaire when presented to students in the main study.

The final section of this chapter gives a summary of the outcome from the pilot study with implications for the main study.

## **5.5 Summary**

In this section we summarise the main findings from the piloting of the questionnaire which aims to examine students' images of mathematics. We also reinforce the significance of this pilot study in informing the main data collection stage during which the questionnaire is distributed to 5<sup>th</sup>-year post-primary students.

### ***Reliability of Sample for Pilot Study:***

Comparisons were drawn between the sample of students who participated in the pilot study and the students for whom the questionnaire was aimed at, namely, 5<sup>th</sup>-year post-primary students studying ordinary level mathematics. Students' profiles were assessed, in particular with regards to the age of students and the Leaving Certificate level of students in the pilot sample. The difference between students in the pilot study and the main sample in terms of age was found to be minor and a small majority of students for the pilot study had studied ordinary level Mathematics for the Leaving Certificate. This suggests similarities occur between the pilot study sample and 5<sup>th</sup>-year ordinary level mathematics students in post-primary school. The significance of these findings lies in the reliability of our sample of students for the pilot study in providing an assessment of the test instrument which will be used for the main data collection phase of our study. It also adds credence to the preliminary analysis performed on the 8 scales which form the predominant section of the questionnaire.

### ***Clarity of Open-ended Questions:***

The open-ended questions posed in Section A of the questionnaire were shown to be clear and easily readable. The open-ended questions were answered by the majority of students in full suggesting that they were understood and the answers given deemed these questions relevant to students.

### ***Consistency of Responses with Previous Research:***

Many of the responses given by our sample of students for the pilot study were consistent with previous research in mathematics education. Findings from the analysis of the open-ended questions which relate to previous research include the following:

- Students' earliest memories of mathematics often related to specific types of mathematics and, in particular, methods of rote-learning which ties in with De Corte et al (1996) and Wang (2005).
- Similarly to Lim (1999), the majority of students in the pilot study agreed that past experiences of mathematics had fuelled their interest or disinterest in mathematics.
- The most frequent influence on students' interest or disinterest in mathematics based on past experiences was found to be relating to teachers and this finding ties in with Hoyles (1982).
- For the pilot study, students considered their mathematics teacher to have influenced them most in mathematics, with parents being the second most influential factor. Similar results can be found in Lim (1999).
- Influence from parents and family was expressed by students mainly in the form of encouragement and support. This was also found to be true in the studies by Fennema & Sherman (1976) and Lim (1999).
- Similarly to Tait-McCutcheon (2008), the most frequent response given by students in the pilot study when accounting for the grade they received for mathematics in the Junior Certificate was that they had studied/worked hard to achieve the grade.
- The variety of responses given by students regarding the utility of mathematics in everyday life concurs with the findings of Hill (2008).

### ***Reliability of Scales:***

The reliability of the 8 scales used for the pilot questionnaire was tested by assessing the internal consistency of each of the scales for the pilot study sample. The internal consistency was found to be good or very good for all scales used in Section B of the questionnaire, with Cronbach alpha scores ranging between .726 and .883. This implies that the scales chosen for the questionnaire are reliable for testing the attitudes, beliefs, emotions, motivation and self-concept of students in the sample used.

### ***Attitude toward Mathematics of Sample:***

The students' attitudes towards mathematics were examined by means of the Enjoyment of Mathematics Scale (Aiken, 1974), Value of Mathematics Scale (Aiken, 1974) and Attitude toward Success in Mathematics Scale (Fennema & Sherman, 1976). Students were found, on average, to have a positive attitude toward mathematics and appeared to enjoy and value mathematics to an extent. In particular, students were found to hold extremely positive attitudes toward success in mathematics.

### ***Motivation in Mathematics of Sample:***

The students' motivation in mathematics was tested using the Fennema-Sherman Effectance Motivation in Mathematics Scale (1976). For the pilot study, the sample of students were found to be motivated in mathematics to a certain degree, but were not as highly motivated as might have been expected considering students decidedly positive attitude to mathematical success.

### ***Beliefs about Mathematics of Sample:***

Findings from the pilot study regarding students' beliefs about mathematics were investigated using both Schoenfeld's (1989) Beliefs about Mathematics Scale and the Mathematics as a Male Domain scale taken from Fennema & Sherman



(1976). Students were seen to hold strong positive beliefs regarding the appropriateness of mathematics for females. On the other hand, students scored relatively low on the Beliefs about Mathematics Scale in comparison to many of the other scales indicating that students were unsure regarding their beliefs about mathematics and learning mathematics.

### ***Self-Concept in Mathematics of Sample:***

The sampled students' self-concept in mathematics was examined by means of the adapted version of Gourgey's Mathematical Self-concept scale (1982). Findings from the preliminary analysis indicated that students' scores on the Self-concept scale were considerably lower than for the attitude scales for example. The mean score for self-concept was similar to the mean score for the Anxiety scale suggesting a consistency between the lower self-concept and higher anxiety levels as found in previous research studies discussed in the literature review in Chapter 2.

### ***Emotions about Mathematics of Sample:***

Emotions regarding mathematics were tested for the sample in our pilot study using Fennema & Sherman's Anxiety about Mathematics Scale (1976). The pilot study found that the Anxiety scale had the lowest mean total score for students in the sample, only slightly bordering on the positive suggesting that while students are not overly anxious about mathematics, they are not entirely free from anxiety either. The lower score found for the Anxiety scale suggests that findings from this pilot study are consistent with previous research highlighting anxiety about mathematics as one of the major concerns for students in mathematics.

### ***Implications for the Main Study:***

The findings from the pilot study outlined in the summary suggest that the questionnaire used for the pilot study will be a reliable and appropriate test instrument for the main study in order to gain an insight into Irish post-primary students' images of mathematics. The questionnaire will provide a means of

examining students' attitudes, beliefs, self-concept, emotions, motivation and past experiences regarding mathematics as evidenced from the pilot study.

## **Chapter Six**

### **Examining Students' Image of Mathematics; Analysis of the Quantitative Data**

## **Chapter Six: Examining Students' Image of Mathematics: Analysis of the Quantitative Data**

The analysis of the quantitative data and the qualitative data is discussed in Chapters 6 & 7. The quantitative data is analysed using SPSS version 19 and findings are presented in this chapter (6). The quantitative data consists of all fixed-choice items on the questionnaire, both from the Student Profile section and Section B which is made up of the image of mathematics scales: Enjoyment of Mathematics Scale (Aiken, 1974); Value of Mathematics Scale (Aiken, 1974); Attitude toward Success in Mathematics Scale (Fennema & Sherman, 1976); Effectance Motivation in Mathematics Scale (Fennema & Sherman, 1976); Mathematics as a Male Domain scale (Fennema & Sherman, 1976); Anxiety about Mathematics Scale (Fennema & Sherman, 1976); Mathematical Self-concept scale (Gourgey, 1982); Beliefs about Mathematics Scale (Schoenfeld, 1989). Means, standard deviations and number of students' responses are calculated for all scales and for all scale items. Reliability of the 8 scales is found using Cronbach's alpha. The individual scales are analysed according to the original analysis by the scales' authors. Further analysis is conducted on the 8 scales as a group in order to assess relationships between the scales and possible relationships between the scales and students' gender, students' prior achievement in mathematics and the type of school attended by students. The analyses performed on SPSS include: correlation, partial correlation, principal components factor analysis, multiple regression analysis, analysis of differences between groups of students, independent samples t-tests and one-way between groups ANOVA. Some of the analyses performed are too lengthy for inclusion in this thesis but all analyses are outlined in a longer version of this chapter which is in the CD attached to this thesis (Appendix CD). In chapter 7, the qualitative data is analysed. The qualitative data consists of the five open-ended questions from Section A of the questionnaire survey. Of the five open-ended questions, four include two parts to the question; part (a) and (b), with part (a) comprising tick the box responses. These tick the box responses are analysed on SPSS. For questions with no pre-categorised responses, the constant comparative method of analysis is used to form categories from the qualitative data. As well as analysing the resulting categories from each

individual question on SPSS, students' responses are also discussed in terms of students' past experiences of mathematics, factors influencing students' images of mathematics, students' causal attributes for success or failure in mathematics and the five categories of images of mathematics found by Lim (1999); namely the absolutist image, utilitarian image, symbolic image, problem-solving image and enigmatic image (as discussed in Section 2.1.4).

In this chapter we present the findings from the quantitative data analysis. An analysis was carried out on the Student Profile section of the questionnaire which looks at the sample of students in our sample with regards to their gender, the post-primary schools attended, co-educational status of schools, the attendance of a Project Maths pilot school and prior achievement in mathematics. Section B of the questionnaire survey was analysed quantitatively. Section B comprises the 8 image of mathematics scales examining students' attitudes, motivation, beliefs, self-concept and anxiety regarding mathematics. The scales were analysed according to the original analyses by the scales' authors as well as further analyses on the 8 scales combined as used in our study.

### ***Section 6.1: Student Profile***

A total of 356 post-primary students completed the questionnaire survey. The students were aged between 15 and 18 years. Their mean was 16.16 which was as expected for students in 5<sup>th</sup> year of post-primary school. The gender of students who completed the questionnaire is shown in Table 6.1. In the table, valid percent refers to the percent of students who actually completed the survey. While the valid percent figure differs from the percent figure in later tables, for Table 6.1 these figures are the same as gender was known for all students.

Gender of Student
-------------------

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Male	158	44.4	44.4	44.4
	Female	198	55.6	55.6	100.0
	Total	356	100.0	100.0	

**Table 6.1 Gender of Students**

Male students numbered 158 or 44.4% of the sample and female students numbered 198 comprising 55.6% of the sample. Although slightly more females than males took part in the survey, the sample of students is fairly evenly divided in terms of gender.

The student profile was also analysed in terms of co-educational status. Frequencies for the types of post-primary schools and co-educational status of schools can be found on the Appendix CD. Combining the co-educational status with the type of post-primary school attended, we obtain 8 sub-categories of post-primary schools as follows:

- 1) *Single-sex Boys Secondary School.*
- 2) *Single-sex Boys Fee-paying School.*
- 3) *Single-sex Girls Secondary School.*
- 4) *Single-sex Girls Fee-paying School.*
- 5) *Co-educational Secondary School.*
- 6) *Co-educational Vocational School.*
- 7) *Co-educational C+C School.*
- 8) *Co-educational Fee-paying School.*

Table 6.2 displays the frequencies for each of these 8 sub-categories. It can be seen that single-sex schools were attended only in the categories of secondary schools and fee-paying schools which is to be expected as vocational and C+C schools in Ireland are co-educational. Single-sex schools account for 40.72% of post-primary schools attended by students in our sample. This is similar to the percentage of single-sex schools in Ireland as a whole: 44.31%. The largest individual sub-category in our study was co-educational vocational schools with 99 students (27.81%). In Ireland,

there are more vocational schools than any other type of post-primary school from the 8 sub-categories listed above, accounting for 34.16% of schools. However the percentage of students attending vocational schools in Ireland is 15.20%, with the majority attending secondary schools (usually secondary schools are much larger than vocational schools). The percentage of students in our sample attending vocational schools is larger than the percentage of students attending vocational schools in Ireland as the vocational schools contacted for this study tended to agree to participate more readily than the other school types. The smallest sub-category was single-sex boys' fee-paying with only 14 students (3.93%) attending this type of post-primary school. This is similar to the percentage of students attending single-sex boys' fee-paying schools in Ireland: 3.16%. Discrepancies between the number and percentage of students attending post-primary school categories in our study and for Ireland as a whole were due to the difficulties encountered in school participation and the process of returning consent forms and questionnaires as discussed in Chapter 4, Section 4.3.2.4.

School Type/Category						
Post-primary School Attending			Frequency	Percent	Percent Total	Cumulative Percent
1.00 Single-sex Boys	Valid	Secondary School	39	73.6	10.95	10.95
		Fee-paying School	14	26.4	3.93	14.89
		Total	53	100.0	14.89	
2.00 Single-sex Girls	Valid	Secondary School	66	71.7	18.54	33.42
		Fee-paying School	26	28.3	7.3	40.72
		Total	92	100.0	25.84	
3.00 Co-educational	Valid	Secondary School	62	29.4	17.42	58.14
		Vocational School	99	46.9	27.81	85.95
		C+C School	28	13.3	7.86	93.81
		Fee-paying School	22	10.4	6.18	100.0
		Total	211	100.0	59.27	

**Table 6.2: Co-educational status of Post-primary School Categories**

As mathematics achievement had been shown to be linked to students' images of mathematics, the student profile section of the questionnaire also requested students to state the level of mathematics studied for the Junior Certificate as well as the grade achieved. The students who took part in the survey for our study were all taking ordinary level mathematics for the Leaving Certificate but it was expected that at least some of these students would have studied higher level mathematics previously. From Table 6.3 it can be seen that 95 students had studied higher level Junior Cert mathematics totalling 26.7% of the sample. The majority, 250 students or 70.2%, had studied ordinary level mathematics at Junior Cert level while a small number of students – 8 students and 2.2% of total – had taken foundation level mathematics for the Junior Cert. 3 students did not answer this question.



Junior Certificate Mathematics Level					
		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Higher Level	95	26.7	26.9	26.9
	Ordinary Level	250	70.2	70.8	97.7
	Foundation Level	8	2.2	2.3	100.0
	Total	353	99.2	100.0	
Missing	Not Given	3	.8		
Total		356	100.0		

**Table 6.3: Junior Certificate Mathematics Level**

In the question asking students to state the grade they had received for mathematics in the Junior Cert, the options provided were Grade A, Grade B, Grade C and Other. The option “Other” covers grades D, E and F. The option “Other” was chosen as students may have felt uncomfortable selecting an E or F grade. Grades were self-reported by students. Table 6.4 indicates that the most commonly received grade was Grade B with 130 students (36.5%) receiving this grade. This is closely followed by Grade C with 118 students (33.1%) obtaining this grade for mathematics. In our sample, 57 students or 16.0% of the sample chose the Other option for this question. The least common grade received for mathematics in the Junior Cert for our sample was Grade A with only 45 students receiving this grade – 12.6% of the sample who completed the survey. In our sample, 6 students did not answer the question.

Junior Certificate Mathematics Grade					
		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Grade A	45	12.6	12.9	12.9
	Grade B	130	36.5	37.1	50.0
	Grade C	118	33.1	33.7	83.7
	Other	57	16.0	16.3	100.0
	Total	350	98.3	100.0	
Missing	Not Given	6	1.7		
Total		356	100.0		

**Table 6.4: Junior Certificate Mathematics Grade**

In order to obtain a clearer insight into the prior achievement of the students who took part in our survey we also combined the Junior Cert mathematics level and grade giving the following sub-categories:

- *Higher Level Grade A*
- *Higher Level Grade B*
- *Higher Level Grade C*
- *Higher Level Other*
- *Ordinary Level Grade A*
- *Ordinary Level Grade B*
- *Ordinary Level Grade C*
- *Ordinary Level Other*
- *Foundation Level Grade A*
- *Foundation Level Grade B*
- *Foundation Level Grade C*
- *Foundation Level Other.*

These 12 sub-categories of mathematics grades are displayed in Table 6.5. The first row in Table 6.5 refers to students who did not state the mathematics level they had studied for the Junior Certificate. The students who did not provide their maths level for Junior Cert did not provide their grade either, i.e. for the 3 students who did not state the maths level, 100% of these students (i.e. all 3) did not state their grade. The most frequently received grade for students in the Junior Cert mathematics exam was an ordinary level grade B as 105 students (29.49% of the sample) received this grade. This was closely followed by an ordinary level grade C with 85 students (23.88%) receiving this grade. The third most frequent sub-category of Junior Cert mathematics grade was an ordinary level grade A which was obtained by 35 students – 9.83% of the sample. Almost the same number of students (33-students/9.27%) stated their grade as higher level ‘Other’ suggesting that almost as many students barely passed or even failed higher level Junior Cert mathematics as received an ordinary level grade A. Grades received at foundation level accounted for the smallest percentages

of students which is unsurprising since only 8 students had taken foundation level mathematics at Junior Cert. Of the 356 students who took part in our study, only 9 reported receiving a higher level grade A for Junior Cert level mathematics. This finding is perhaps to be expected, as students who received a high grade for Junior Cert higher level mathematics would presumably continue studying higher level mathematics for the Leaving Certificate. Indeed that 9 of the students sampled had achieved a grade A for higher level Junior Cert mathematics would raise the question as to why these students were studying ordinary level mathematics for the Leaving Cert, especially at this early stage of the Leaving Cert curriculum (students completed questionnaires during the first school term and therefore had been studying the Leaving Cert curriculum for at most 3 months).

Junior Certificate Mathematics Grade						
Junior Certificate Mathematics Level			Frequency	Percent	Percent Total	Cumulative Percent
Not Given	Missing	Not Given	3	100.0	0.84	0.84
Higher Level	Valid	Grade A	9	9.5	2.53	3.37
		Grade B	21	22.1	5.90	9.27
		Grade C	32	33.7	8.99	18.26
		Other	33	34.7	9.27	27.53
		Total	95	100.0	26.69	
Ordinary Level	Valid	Grade A	35	14.0	9.83	37.36
		Grade B	105	42.0	29.49	66.85
		Grade C	85	34.0	23.88	90.73
		Other	23	9.2	6.46	97.19
		Total	248	99.2	69.66	
	Missing	Not Given	2	.8	0.56	97.75
	Total		250	100.0	70.22	
Foundation Level	Valid	Grade A	1	12.5	0.28	98.03
		Grade B	4	50.0	1.12	99.15
		Grade C	1	12.5	0.28	99.43
		Other	1	12.5	0.28	99.71
		Total	7	87.5	1.96	
	Missing	Not Given	1	12.5	0.28	100.00
	Total		8	100.0	2.24	

**Table 6.5: Sub-Categories of Junior Certificate Mathematics Grade**

After the sample of schools had been selected to take part in our study, we decided to verify if any of these schools had taken part in the piloting of Project Maths – the new mathematics curriculum introduced in Ireland (see Project Maths website). While all schools were now studying the new Project Maths course for Leaving Cert, 20 schools had taken part in the piloting of the Project Maths course. If any of the schools in our study had participated as a pilot school for Project Maths, then the 5<sup>th</sup> year students from these schools would have studied Project Maths throughout post-primary school and would be better acquainted with the Project Maths ethos than would students who were only recently introduced to the Project Maths curriculum. From the sample of students who completed our questionnaire, 51 students or 14.3% attended pilot schools for Project Maths; see Table 6.6. Although only a small minority, these students would provide a basis for examining any preliminary differences between students of the old mathematics curriculum and students of the new Project Maths curriculum in terms of their image of mathematics.

Project Maths					
		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Yes	51	14.3	14.3	14.3
	No	305	85.7	85.7	100.0
	Total	356	100.0	100.0	

**Table 6.6: Project Maths Pilot School**

The student profile section of the survey, as well as providing background information on our sample for our study, also provides a means for examining students' images of mathematics in more detail, in terms of students' gender, post-primary school attended and prior achievement in mathematics. Schools taking part in our study were selected on a proportional representative basis and therefore it is important that students for our study are also analysed in terms of the type of post-primary school they attend as well as the co-educational status of the school. As Project Maths has emerged as a topic of much discussion within the Irish mathematics education community, it was also deemed appropriate that students who

had attended the Project Maths pilot schools would be identified in the study as a category of analysis. Based on the previous research into images of mathematics as well as associated research issues (discussed in Chapter 2), students' gender as well as students' prior achievement in mathematics were also topics which required consideration when analysing students' responses in this questionnaire survey.

## **Section 6.2: Section B**

Section B of the questionnaire was made up of 84 items from 8 Likert-type scales by Aiken (1974) *Enjoyment of Mathematics Scale* and *Value of Mathematics Scale*, Fennema & Sherman (1976) *Attitude toward Success in Mathematics Scale*, *Effectance Motivation in Mathematics Scale*, *Mathematics as a Male Domain scale* and *Anxiety about Mathematics Scale*, Gourgéy (1982) *Mathematical Self-concept scale* and Schoenfeld (1989) *Beliefs about Mathematics Scale*. The 84 items from the scales were presented in a random order to students so that students would not identify patterns in responding to the items.

### **Section 6.2.1: Preliminary Analysis of Items**

A preliminary analysis of the 84 items is shown in Table 6.7 below in which the mean score  $\bar{x}$  and standard deviation **SD** for each item is provided as well as the number of students **N** who answered each item. Although some authors disagree with the use of means to analyse Likert scales (see Section 4.3.2.1) the original authors of the scales used in this study all analyse scale and item means and standard deviations. This is the main reason that we analyse for means and standard deviations in this section. The items appear in Table 6.7 divided according to the scale from which they originate and not in the order they were given to students. However the items remain numbered according to their position within Section B of the questionnaire. The “unsure” score for each of the items in Section B of the questionnaire is 3, with a score above 3 suggesting a more positive attitude, belief, motivation, self-concept or emotion regarding mathematics while a score below 3 indicates a more negative response. The minimum score for each item is 1 and the maximum score is 5.

Section B	Item	N	$\bar{X}$	SD
	<b>Enjoyment of Mathematics Scale</b>			
<b>Q1</b>	Mathematics makes me feel uneasy and confused.	355	2.88	1.21
<b>Q2</b>	I have always enjoyed studying mathematics at school.	355	2.57	1.20
<b>Q3</b>	I am interested and willing to acquire further knowledge of mathematics.	356	3.00	1.21
<b>Q29</b>	I am interested and willing to use mathematics outside school and on the job.	352	2.99	1.25
<b>Q30</b>	Mathematics makes me feel uncomfortable and nervous.	352	3.27	1.19
<b>Q36</b>	Mathematics is enjoyable and stimulating to me.	352	2.51	1.18
<b>Q48</b>	Mathematics is dull and boring because it leaves no room for personal opinion.	350	2.96	1.25
<b>Q60</b>	I have never liked mathematics, and it is my most dreaded subject.	349	3.13	1.32
<b>Q69</b>	Mathematics is very interesting, and I have usually enjoyed classes in this subject.	349	2.76	1.21
<b>Q74</b>	I enjoy going beyond the assigned work and trying to solve new problems in mathematics.	348	2.17	1.18
<b>Q78</b>	I would like to develop my mathematical skills and study this subject more.	346	2.92	1.23
	<b>Value of Mathematics Scale</b>			
<b>Q4</b>	Mathematics has contributed greatly to science and other fields of knowledge.	356	3.77	1.08
<b>Q5</b>	Mathematics is a very worthwhile and necessary subject.	355	3.69	1.13
<b>Q6</b>	Mathematics is not important in everyday	356	3.55	1.23

	life.			
<b>Q7</b>	There is nothing creative about mathematics; it's just memorizing formulas and things.	356	3.00	1.30
<b>Q31</b>	Mathematics is less important to people than art or literature.	353	3.30	1.26
<b>Q32</b>	Mathematics helps develop a person's mind and teaches him to think.	351	3.84	0.92
<b>Q49</b>	An understanding of mathematics is needed by artists and writers as well as scientists.	348	2.99	1.11
<b>Q61</b>	Mathematics is not important for the advance of civilization and society.	349	3.77	1.12
<b>Q75</b>	Mathematics is needed in order to keep the world running.	347	3.78	1.05
<b>Q83</b>	Mathematics is needed in designing practically everything.	347	3.54	1.11
	<b>Attitude Toward Success in Mathematics Scale</b>			
<b>Q8</b>	I'd be happy to get top grades in mathematics.	353	4.58	0.71
<b>Q9</b>	Being regarded as smart in mathematics would be a great thing.	353	4.28	0.86
<b>Q10</b>	If I had good grades in mathematics, I would try to hide it.	354	4.32	0.88
<b>Q11</b>	I don't like people to think I'm smart in mathematics.	354	4.08	1.04
<b>Q33</b>	It would make me happy to be recognized as an excellent student in mathematics.	351	3.91	1.07
<b>Q34</b>	Being first in a mathematics competition would make me pleased.	352	3.85	1.08
<b>Q35</b>	If I got the highest grade in mathematics I'd prefer no one knew.	352	3.94	1.05

<b>Q50</b>	I'd be proud to be the outstanding student in mathematics.	349	3.94	1.09
<b>Q51</b>	People would think I was a 'swot' if I got A's in mathematics.	347	3.44	1.37
<b>Q62</b>	It would be really great to win a prize in mathematics.	349	3.62	1.10
<b>Q70</b>	Winning a prize in mathematics would make me feel unpleasantly conspicuous.	348	3.45	0.99
<b>Q81</b>	It would make people like me less if I were a really good mathematics student.	348	4.03	1.03
	<b>Effectance Motivation in Mathematics Scale</b>			
<b>Q12</b>	When a mathematics problem arises that I can't immediately solve, I stick with it until I have the solution.	353	3.05	1.13
<b>Q13</b>	I am challenged by mathematics problems I can't understand immediately.	353	3.57	1.09
<b>Q14</b>	Mathematics puzzles are boring.	353	2.91	1.22
<b>Q15</b>	I do as little work in mathematics as possible.	353	3.77	1.06
<b>Q36</b>	Mathematics is enjoyable and stimulating to me.	352	2.51	1.18
<b>Q37</b>	Figuring out mathematical problems does not appeal to me.	353	2.77	1.25
<b>Q38</b>	I would rather have someone give me the solution to a difficult problem than to have to work it out for myself.	352	3.11	1.27
<b>Q52</b>	Once I start trying to work on a mathematics puzzle, I find it hard to stop.	347	2.40	1.24
<b>Q53</b>	I don't understand how some people can spend so much time on mathematics and seem to enjoy it.	348	2.71	1.30



<b>Q63</b>	I like mathematics puzzles.	342	2.69	1.23
<b>Q71</b>	The challenge of mathematics problems does not appeal to me.	346	2.68	1.14
<b>Q79</b>	When a question is left unanswered in mathematics class, I continue to think about it afterward.	348	2.75	1.29
	<b>Beliefs about Mathematics Scale</b>			
<b>Q16</b>	Mathematics can be done correctly in only one way.	351	3.87	0.99
<b>Q17</b>	The best way to do well in mathematics is to memorize all the formulas.	353	3.29	1.08
<b>Q39</b>	Real mathematics problems can be solved by common sense instead of the rules you learn in school.	351	3.10	1.14
<b>Q54</b>	To solve mathematics problems you have to be taught the right procedure, or you can't do anything.	347	2.67	1.12
<b>Q64</b>	Everything important about mathematics is already known by mathematicians.	347	3.26	1.12
<b>Q76</b>	In mathematics you can be creative and discover things for yourself.	347	2.98	1.18
	<b>Mathematics as a Male Domain scale</b>			
<b>Q18</b>	I would trust a woman just as much as I would trust a man to figure out important calculations.	353	4.11	1.19
<b>Q19</b>	Women certainly are logical enough to do well in mathematics.	353	4.18	1.09
<b>Q20</b>	I would have more faith in the answer for a mathematics problem solved by a man than a woman.	353	3.92	1.22
<b>Q21</b>	I would expect a woman mathematician to be a masculine type of person.	354	4.09	1.11

<b>Q40</b>	Studying mathematics is just as appropriate for women as for men.	351	4.33	0.93
<b>Q41</b>	It's hard to believe a female could be a genius in mathematics.	349	4.40	0.98
<b>Q42</b>	Mathematics is for men; arithmetic is for women.	349	4.30	0.96
<b>Q55</b>	Males are not naturally better than females in mathematics.	350	3.37	1.41
<b>Q65</b>	Girls can do just as well as boys in mathematics.	349	4.37	1.03
<b>Q72</b>	When a woman has to solve a mathematics problem, it is feminine to ask a man for help.	348	3.83	1.11
<b>Q82</b>	Girls who enjoy studying mathematics are a bit peculiar.	347	3.80	1.17
<b>Q84</b>	Females are as good as males in geometry.	348	4.22	1.08
	<b>Mathematical Self-concept scale</b>			
<b>Q22</b>	I don't ask questions in mathematics classes because mine sound stupid.	354	3.42	1.33
<b>Q23</b>	Whenever I do a mathematics problem, I am sure that I have made a mistake.	355	2.84	1.17
<b>Q24</b>	I can understand mathematics better than most people.	352	2.35	1.11
<b>Q25</b>	When I do mathematics, I feel confident that I have done it correctly.	353	2.75	1.09
<b>Q43</b>	I have never been able to think mathematically.	349	3.16	1.23
<b>Q44</b>	I have a good mind for mathematics.	348	2.86	1.15
<b>Q56</b>	It takes me much longer to understand mathematical concepts than the average person.	348	3.05	1.15
<b>Q57</b>	I have never felt myself incapable of learning	349	3.28	1.13

	mathematics.			
<b>Q66</b>	If I can understand a mathematics problem, then it must be an easy one.	349	2.80	1.23
<b>Q67</b>	When I have difficulty with mathematics, I know I know I can handle it if I try.	347	3.38	1.04
<b>Q73</b>	I have no more trouble understanding mathematics than any other subject.	346	2.67	1.22
<b>Q77</b>	I don't have a good enough memory to learn mathematics.	346	3.27	1.22
	<b>Anxiety about Mathematics Scale</b>			
<b>Q1</b>	Mathematics makes me feel uneasy and confused.	355	2.88	1.21
<b>Q26</b>	I haven't usually worried about being able to solve mathematics problems.	352	3.09	1.07
<b>Q27</b>	I usually have been at ease in mathematics classes.	354	3.05	1.16
<b>Q28</b>	I get a sinking feeling when I think of trying hard mathematics problems.	354	3.01	1.25
<b>Q30</b>	Mathematics makes me feel uncomfortable and nervous.	352	3.27	1.19
<b>Q45</b>	Mathematics doesn't scare me at all.	347	3.00	1.24
<b>Q46</b>	I usually have been at ease during mathematics tests.	349	2.71	1.24
<b>Q47</b>	My mind goes blank and I am unable to think clearly when working mathematics.	348	3.07	1.23
<b>Q58</b>	It wouldn't bother me at all to take more mathematics classes.	349	2.90	1.28
<b>Q59</b>	Mathematics makes me feel uncomfortable, restless, irritable, and important.	348	3.14	1.29
<b>Q68</b>	A mathematics test would scare me.	345	3.12	1.24
<b>Q80</b>	I almost never have become distressed	346	2.42	1.20

	during a mathematics test.			
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**Table 6.7: Item statistics (Number Responses, Mean and Standard Deviation)**

The lowest mean score for the items in Table 6.7 was for Q74 “*I enjoy going beyond the assigned work and trying to solve new problems in mathematics*” which is part of Aiken’s (1974) Enjoyment of Mathematics Scale and, in our study, received a mean score of 2.17. The highest mean score was for Q8 “*I’d be happy to get top grades in mathematics*” which is part of Fennema & Sherman’s (1976) Attitude toward Success in Mathematics Scale and, in our study, received a mean score of 4.58.

#### **Attitude Items:**

For the Enjoyment of Mathematics Scale, 9 out of the 11 items had a mean score below 3 indicating a general negative attitude to mathematics within this scale. Of the ten items making up the Value of Mathematics Scale, 8 had a mean score above 3 suggesting that responses to these items tend towards a positive attitude in terms of value. All items in the Attitude toward Success in Mathematics Scale received a mean score above 3 with 5 out of the 12 items recording a mean score above 4 signifying that students generally held extremely positive attitudes toward success in mathematics.

#### **Motivation Items:**

The Effectance Motivation in Mathematics Scale is composed of 12 items, 8 of which received a mean score below the “unsure” score of 3. The remaining 4 items scored just slightly above 3. The mean scores for items in this scale indicate that students in general had a low motivation in mathematics.

#### **Belief Items:**

The Beliefs about Mathematics Scale shows that mean scores for 4 out of the 6 items were slightly above 3 with the other 2 items slightly below 3. In general the items recorded mean scores close to the “unsure” score of 3 suggesting that beliefs

were neither extremely positive nor extremely negative with students seemingly unsure regarding beliefs about the nature of mathematics. Mean item scores for the Mathematics as a Male Domain scale were all above the “unsure” score of 3, with 8 of the 12 scale items having a mean score above 4. This shows that students tend to have positive beliefs regarding mathematics and gender.

#### **Self-concept Items:**

The mean scores for items on the Mathematical Self-concept scale were evenly divided with 6 of the 12 items showing mean scores below 3 and 6 items showing mean scores slightly above 3. The mean scores suggest that students have a negative mathematical self-concept with regards to certain aspects of the scale while other item means tend to indicate that students are unsure about their ability in mathematics.

#### **Emotion Items:**

The 12 items of the Anxiety about Mathematics Scale show the most consistency between mean scores with very little deviation from the “unsure” score of 3. In our study, 4 items record a mean score below 3, the lowest mean score is 2.42 while the 8 items with mean scores above 3 are only slightly positive – the highest mean for the scale is 3.27. Item means suggest at this stage that students in general are not seen to have highly positive or highly negative emotions regarding mathematics.

These comments are only the findings of a preliminary analysis and further analysis of scales and students’ responses will provide a more in-depth insight into students’ attitudes, beliefs, motivation, self-concept and emotions regarding mathematics.

### Section 6.2.2: Preliminary Analysis of Scales

The mean scores for each of the 8 scales  $\bar{x}$  are shown in Table 6.8 together with standard deviations **SD**, variance of scores **Var** and the number of students **N** who answered each scale, i.e., the number of students who answered all items constituting a scale. This table indicates students' response to each scale as a whole, rather than to individual items within the scales. As an acknowledgement of the debate concerning the use of means to analyse Likert scales, the median score for each scale is also provided for each scale in the mean ( $\bar{x}$ ) column.

Scale	N	$\bar{x}$	SD	Var
Enjoyment of Mathematics Scale (Aiken, 1974)	342	31.07 (31.0)	8.96	80.28
Value of Mathematics Scale (Aiken, 1974)	343	35.28 (36.0)	6.22	38.73
Attitude toward Success in Mathematics Scale (Fennema & Sherman, 1976)	340	47.20 (48.0)	7.01	49.14
Effectance Motivation in Mathematics Scale (Fennema & Sherman, 1976)	330	34.91 (35.0)	8.76	76.77
Beliefs about Mathematics Scale (Schoenfeld, 1989)	337	19.16 (19.0)	2.99	8.96
Mathematics as a Male Domain scale (Fennema & Sherman, 1976)	341	48.62 (50.0)	8.55	73.10
Mathematical Self-concept scale (Gourgey, 1982)	336	35.85 (37.0)	8.88	78.78
Anxiety about Mathematics Scale (Fennema & Sherman, 1976)	335	35.57 (36.0)	9.14	83.57

**Table 6.8: Scale Mean, Standard Deviation, Variance and Number of Respondents**

From Table 6.8 the number of students who responded to each scale as a whole differs slightly but not to any extreme. The greatest difference between the number of respondents is N=343 for the Value of Mathematics Scale and N=330 for the Effectance Motivation scale. No scale was answered by all 356 students who

completed the survey but this was because some students did not complete the questionnaire as they ran out of time, or found the questionnaire too long, or indeed were unsure of how to respond to some items. Only a small number of such cases occurred; they are to be expected given the size of the sample. Every item in each of the 8 scales allocates 3 points to a response which is “unsure”, i.e. neither positive nor negative. By comparing the mean total score of a scale to the score received if all items are “unsure”, we can detect if the students’ responses were positive or negative for each scale.

The Enjoyment of Mathematics Scale had a mean score of 31.07 which is just under the “unsure” score of 33. This suggests that the mean response from students indicates a low enjoyment of mathematics. The Value of Mathematics Scale on the other hand had a mean score of 35.28 which was above the “unsure” score of 30 suggesting that students from the sample had quite a positive attitude toward mathematics in terms of its value. Similarly, the mean score for the Attitude toward Success in Mathematics Scale showed that students had a very positive attitude toward mathematical success with a mean of 47.20 which is much higher than the “unsure” score of 36. For the Effectance Motivation in Mathematics Scale the mean score of 34.91 was not very different from the “unsure” score of 36 which suggests that students were neither highly motivated nor had they very low levels of motivation. The mean could suggest an indifference or uncertainty with regards to their motivation in mathematics. The Beliefs about Mathematics Scale was found to be slightly above the “unsure” score of 18 with a mean of 19.16. Although the mean score for students’ beliefs is slightly positive, again it is not entirely dissimilar from the “unsure” score which could indicate students are unsure about their beliefs concerning the nature of mathematics and also regarding the interpretation of some of the questions as discussed in Section 6.3. The Mean score for the Mathematics as a Male Domain scale was 48.62, the highest mean of all the scales indicating a generally positive perception of mathematics as being a domain for both males and females. For the Mathematical Self-concept scale students mean score was 35.85 which is similar to the “unsure” score of 36. The “unsure” score for the Anxiety about

Mathematics Scale is also 36 and the Anxiety scale received an almost identical mean score to the Self-concept scale of 35.57. The latter two scales measuring students' self-concept and anxiety regarding mathematics had high variance of scores (78.78 and 83.57 respectively). This variance could suggest that some students in the study had quite low self-concept and high anxiety levels while others had quite high self-concept and low levels of anxiety.

In previous research studies it was observed that significant gender differences occurred in particular with regards to students' self-concept of ability in mathematics and their anxiety about mathematics. Therefore mean scores for each of the 8 scales were obtained for students grouped by gender. To further analyse the scales in terms of student profiles, the mean scores were also obtained for the following groups:

- *Co-educational Status of Post-primary School.*
- *Type of Post-primary School.*
- *Junior Certificate Mathematics Level.*
- *Junior Certificate Mathematics Grade.*
- *Project Maths Pilot School.*

The mean scores for the five groupings listed can be found in the extended version of this chapter on the Appendix CD.

### **Section 6.2.3: Gender of Students:**

The mean and standard deviation for each scale by gender is displayed in Table 6.9 with mean scores for females seen to be lower on 7 of the 8 scales.



Scale	$\bar{X}$ Males	SD Males	$\bar{X}$ Females	SD Females
Enjoyment of Mathematics Scale	33.07	8.73	29.60	8.98
Value of Mathematics Scale	36.00	6.49	34.97	6.94
Attitude toward Success in Mathematics Scale	46.46	7.14	47.79	6.87
Effectance Motivation in Mathematics Scale	36.03	8.53	34.02	8.86
Beliefs about Mathematics Scale	19.31	2.85	19.20	3.74
Mathematics as a Male Domain scale	44.93	9.44	51.52	6.46
Mathematical Self-concept scale	37.95	8.26	34.39	9.28
Anxiety about Mathematics Scale	38.96	8.50	33.13	9.21

**Table 6.9: Scale Means and Standard Deviation by Gender**

The main differences between the genders in terms of mean scores can be seen for the Enjoyment of Mathematics Scale, Mathematics as a Male Domain scale, Mathematical Self-concept scale and Anxiety about Mathematics Scale. Females had considerably lower means for the enjoyment, self-concept and Anxiety scales suggesting that females have a more negative attitude toward mathematics in terms of enjoyment than males, lower self-concept in their mathematical ability and higher anxiety levels regarding mathematics. On the other hand, females scored considerably higher on the Mathematics as a Male Domain scale suggesting that females have more positive beliefs about women in mathematics than do males.

### ***Section 6.3: Reliability of Scales***

The reliability of a scale indicates how free it is from random error (Pallant, 2010). For our study, the reliability of the 8 scales used in Section B of the questionnaire was assessed in terms of the internal consistency of each scale. The internal consistency refers to the degree to which the items that make up a scale are all measuring the same underlying attribute. This reliability was measured using Cronbach's alpha coefficient with alphas for each of the scales displayed in Table 6.10. DeVellis (2003) states that the Cronbach alpha value should ideally be above .7. However, as the Cronbach alpha is sensitive to the number of items in the scale, this can lead to lower alphas in cases where scales have fewer than ten items.

<b>Scale</b>	<b>Cronbach's Alpha</b>
Enjoyment of Mathematics Scale (Aiken, 1974)	.87
Value of Mathematics Scale (Aiken, 1974)	.74
Attitude toward Success in Mathematics Scale (Fennema & Sherman, 1976)	.80
Effectance Motivation in Mathematics Scale (Fennema & Sherman, 1976)	.84
Beliefs about Mathematics Scale (Schoenfeld, 1989)	.21
Mathematics as a Male Domain scale (Fennema & Sherman, 1976)	.86
Mathematical Self-concept scale (Gourgey, 1982)	.86
Anxiety about Mathematics Scale (Fennema & Sherman, 1976)	.86

**Table 6.10: Reliability of Scales**

Of the 8 scales, 6 were found to have Cronbach alpha values above .8 indicating a very good internal consistency – Enjoyment of Mathematics (.87), Attitude toward Success in Mathematics (.80), Effectance Motivation (.84), Mathematics as a Male Domain (.86), Mathematical Self-Concept (.86) and Anxiety about Mathematics (.86). Of the remaining 2 scales, Value of Mathematics (.73) was found to have a Cronbach alpha value above .7 which indicates a good internal consistency. The Cronbach alpha for the final scale, Beliefs about Mathematics, was only .21 which is very low. This low value can be explained in part by the number of items which make up the scale – 6 items. As previously stated, the Cronbach alpha can be influenced and decreased in cases where scales have fewer than ten items. However, as the reliability found for the Beliefs about Mathematics Scale was extremely low, findings regarding this scale should be interpreted cautiously.

In the original development of the scales used for our study, the authors also assessed the internal reliability of the scales using Cronbach's alpha coefficient. Aiken (1974) in the original analysis of the Enjoyment of Mathematics Scale and Value of Mathematics Scale found Cronbach alpha values of .95 for the Enjoyment scale and .85 for the Value scale. The Cronbach alpha for the Enjoyment of Mathematics Scale in our study was .87 which is lower than that found by Aiken, but

similarly to the original analysis, the Enjoyment scale was found to have a higher reliability than the Value of Mathematics Scale which was .74 in our study. In their original analysis of their scales, Fennema & Sherman (1976) examined the split-half reliabilities of the Attitude toward Success in Mathematics Scale (.87), Effectance Motivation in Mathematics Scale (.87), Mathematics as a Male Domain scale (.87) and Anxiety about Mathematics Scale (.89). The reliability values obtained in our study are quite close to the original values, with Cronbach alphas for the scales in our study found to be .80, .84, .86 and .86. The Mathematical Self-concept scale was originally analysed by Gurgey (1982) who found a very high Cronbach alpha of .96. Although lower than the value in the original analysis of the scale, the Cronbach alpha for the Self-concept scale in our study was still high at .86. As we have seen, the reliability for the Beliefs about Mathematics Scale was very low (.21). The Beliefs about Mathematics Scale was originally part of a much larger test instrument developed by Schoenfeld (1989) and adapted for use by Miller-Reilly (2005) and Wood & Smith (1993) which may have had some effect on the reliability of the scale. In her study on affective issues and learning mathematics, Liston (2009) also found a low reliability for the Beliefs about Mathematics Scale for her sample of Irish third-level students (.43) and Miller-Reilly (2005) found that one of the items *“Real maths problems can be solved by commonsense instead of the maths rules you learn in school”* was difficult to interpret. Thus findings from the Beliefs about Mathematics Scale shall be interpreted with caution.

In order to further examine the internal consistency of the 8 scales used for our questionnaire survey, we also obtained item-scale correlations for each scale. For the Enjoyment of Mathematics Scale, the item-total correlations ranged from .43 to .69 indicating that all items correlated with the Enjoyment scale as a whole. For the Value of Mathematics Scale, 8 of the 10 items correlated between .32 and .57 showing quite good internal consistency. However, 2 items correlated less than .3 with the Value scale suggesting that these items may be measuring something different from the scale as a whole. The items with low correlations were Q31 *Mathematics is less important to people than art or literature* (.26) and Q49 *An*

*understanding of mathematics is needed by artists and writers as well as scientists* (.279). Of the 12 items included in the Attitude toward Success in Mathematics Scale, 10 correlated above .3 with the scale as a whole (values ranging between .31 and .59). Similarly to the Value scale, 2 items of the Success scale correlated less than .3 with the total scale. Q51 *People would think I was a 'swot' if I got A's in mathematics* correlated .26 and Q81 *It would make people like me less if I were a really good mathematics student* correlated .29. In addition, if Q51 were removed from the scale, the Cronbach alpha for the Attitude toward Success scale would increase slightly to .81. Items in the Effectance Motivation in Mathematics Scale had high item-total correlations in most cases, ranging from .35 to .72 with only one item having low correlation with the total scale – Q13 *I am challenged by mathematics problems I can't understand immediately* (-0.15). There appeared to be some confusion among students regarding this item's meaning, with some students' responses to this item inconsistent with their responses to other items in the Motivation scale and may explain the low correlation. Reliability for the Motivation scale increases to .87 if this item were excluded from the scale. As already seen in Table 6.16, the Beliefs about Mathematics Scale was found to have a very low reliability (.21). The item-total correlations for this scale were also found to be very low, with all items correlating below .3 with the total scale. This suggests that for our sample, the items for the Beliefs scale are not measuring one particular aspect of students' beliefs which is consistent with the findings of Liston (2009). For the Mathematics as a Male Domain scale, all items bar one correlated highly with the scale total (.45 to .68). One item Q55 *Males are not naturally better than females in mathematics* had a low correlation .19 which is perhaps due to the wording of the item as some students in our sample appeared to misread this item as *Males are naturally better than females in mathematics*, as some students' responses to this item were inconsistent with their responses to all other items in the Male Domain scale. All item-total correlations were above .3 for the Mathematical Self-concept scale. The correlations were found to be between .36 and .69 indicating a very good internal consistency for the scale. Finally, the Anxiety about Mathematics Scale had very good item-total correlations for 11 of the 12 items (correlations between .39 and .68). One item correlated only

.11 with the total Anxiety scale – Q58 *It wouldn't bother me at all to take more mathematics classes*. The low correlation suggests that this item may be measuring something different from the scale as a whole.

## **Section 6.4: Analysis Performed by Scale Authors**

In this section we look at how the scales were originally analysed by the scales' authors and re-create this analysis as near as possible for the sample of 5<sup>th</sup>-year post-primary students in our study. Scales are grouped in this section according to their authors: Aiken (1974); Fennema & Sherman (1976); Gourney (1982); and Schoenfeld (1989).

### **Section 6.4.1: Aiken (1974)**

In his original analysis of the Enjoyment of Mathematics (E) Scale and the Value of Mathematics (V) Scale, Aiken computed total scores for each scale, variance of total scores and scale means for all students and by gender. These analyses were also performed for our study and have already been discussed in the preliminary analysis section above. Aiken found that the mean scores of men were not significantly different from those of women on either of the two scales. In our study, females scored much lower on the Enjoyment scale than males, but there was no significant difference between the sexes on the Value scale. In Aiken's study, the internal consistency of both scales was analysed by correlating item scores with total scores. Item-total correlations were examined in our study under the section on reliability analysis. The correlation between the E and V scale was .64 for Aiken's original sample, indicating a significant overlap but the scales were not measuring identical variables. Pearson's correlation was computed between the E and V scales for our sample and found to be .54 which is significant at the .01 level. Aiken (1974) also correlated the E and V scales with verbal and mathematics scores on the Scholastic Aptitude Tests and with T-score equivalents of rank in high school graduating class with all correlations found to be significant at the .01 level. For our study, the E Scale and the V Scale were correlated with the variables that were assessed in the Student Profile section of the questionnaire. These variables include

gender of students, co-educational status of post-primary school attending, the type of post-primary school attending, Junior Certificate mathematics level and grade, and attendance of a Project Maths pilot school. As part of the requisite for correlation analysis, some of the variables listed were re-grouped into dichotomous variables. For example, the co-educational status of post-primary schools was divided into *single-sex boys' schools/not*, *single-sex girls' schools/not*, and *co-educational schools/not*. Pearson's correlation values for the E and V scales with the variables listed are displayed in the extended version of this chapter (Appendix CD). Positive correlation values indicate that variables are positively related with high scores on one variable associated with high scores on the other variable. Negative correlation values indicate that variables are negatively related with high scores on one variable associated with low scores on the other variable.

Some of the Student Profile variables were found to have a significant correlation with the E Scale and the V Scale. For the E scale, Gender, Higher Level Grade A and Vocational School had correlations significant at the .01 level and Single-sex Girls' School, Ordinary Level Other and Secondary School had correlations with the E scale that were significant at the .05 level. No significant relationship was found between the E scale and the remaining variables. For the V scale, the Higher Level Grade A and Ordinary Level Grade C variables correlated significantly at the .01 level while Secondary School correlated significantly at the .05 level. All remaining Student Profile variables had no significant correlation with the V scale.

### **Section 6.4.2: Fennema & Sherman (1976)**

Of the 9 scales developed by Fennema & Sherman (1976), 4 are used in our study – the Attitude toward Success in Mathematics (AS) Scale, the Effectance Motivation (E) Scale, the Mathematics as a Male Domain (MD) Scale and the Anxiety about Mathematics (A) Scale. In their analysis of the scales, Fennema and Sherman computed N (number of students who completed each scale), means and standard deviations for each scale. Ns, means and standard deviations for the scales in

our study are displayed in the section on the preliminary analysis. Fennema & Sherman also computed analyses of variance for each scale using grade (year of schooling) and gender as variables. Variance of total scores was also calculated for our study for each of the four scales used. As in the original analysis, gender was used as a variable. Grade was not used as a variable for our study as the sample of students were all in 5<sup>th</sup> year of post-primary school. Variance for the AS, E, MD and A scales are shown in Table 6.11.

<b>Scale</b>	<b>Variance Males</b>	<b>Variance Females</b>
Attitude toward Success in Mathematics Scale	50.96	47.15
Effectance Motivation in Mathematics Scale	72.72	78.59
Mathematics as a Male Domain scale	89.07	41.73
Anxiety about Mathematics Scale	72.32	84.82

**Table 611: Variance for Fennema-Sherman Scales by Gender**

Fennema & Sherman (1976) found frequency distributions for each scale for their sample by gender. Due to the number of analyses performed in this chapter, frequency distributions were rejected in favour of analyses that were more suitable to examining the scales with respect to gender – i.e., Mann-Whitney U Test. In the original analysis of the Fennema-Sherman scales, the correlations between scale scores were computed by gender. The inter-correlations indicated that while scales are interrelated, each scale measures a somewhat different construct. All differences between the sexes were non-significant. Pearson's correlations between the AS, E, MD and A scales by gender for our study are shown in the Appendix CD.

Finally, Fennema & Sherman computed a Principal Components Factor Analysis for males and females. In our study, we also performed a Principal Components Factor Analysis for the four Fennema-Sherman Scales used and as with Fennema & Sherman's analysis, gender differences within the factor analysis

occurred for the Attitude toward Success in Mathematics Scale. Further Factor Analysis can be seen in Section 6.5.

### **Section 6.4.3: Gourgey (1982)**

Gourgey's original analysis of her 27-item Mathematical Self-concept scale is used as a basis for analysing the 12-item subset used in our study. Gourgey found the mean mathematical self-concept for the sample of students as well as the standard deviation and the range of scores. Mean and standard deviation for the Mathematical Self-concept scale as found for our study are listed in Table 6.8. The range of scores found for the Self-concept scale was from 12 to 58. Gourgey calculated the Coefficient alpha for the 27 items: 0.96. The Coefficient alpha for the 12-item subset used in our study was found to be 0.86. In Gourgey's analysis of the Mathematical Self-concept scale, item-total correlations were computed with all but one found to be above .5. Item-total correlations for our study are discussed in the section of this chapter on the reliability of the scales.

A Principal Components factor analysis was performed on the scale items in Gourgey's analysis which showed that most of the variance among items was to be accounted for by a single factor. A Principal Components factor analysis was also performed for the Mathematical Self-concept subset used in our study – see Section 6.5.

When Gourgey tested her Mathematical Self-concept scale with her sample of students, they were also given the Mathematics Anxiety Rating Scale – MARS (Richardson & Suinn, 1972), a test of arithmetic skills (Durost et al., 1970), a list of erroneous statements about mathematics (Gourgey, 1982) and also completed a midterm examination on descriptive statistics. Gourgey's Mathematical Self-concept scale was correlated with each of the other scales and variables completed by students. In our study, the Mathematical Self-concept scale was correlated with each of the other 7 scales completed by students in our sample (see Section 6.5.1). The Self-concept scale was also correlated with students' Junior Cert mathematics level and grade. Pearson's correlations can be found on the Appendix CD. The correlations



between the Mathematical Self-concept scale and students' prior achievement in mathematics were found to be strongest/most significant at the extremes, i.e., the highest achievement and lowest achievement in mathematics for the Junior Certificate.

#### **Section 6.4.4 Schoenfeld (1989)**

In Schoenfeld's original analysis, means, standard deviations and number of respondents were computed for each item. This information is provided for the Beliefs about Mathematics Scale for our sample in Section 6.2.1 previously. Schoenfeld found that sex differences were consistently negligible in his analyses and for our sample, gender differences also appeared insignificant regarding Beliefs about Mathematics Scale. Schoenfeld carried out repeated measures ANOVA with post-hoc comparisons on his entire test instrument, comparing maths scores with scores for English and social studies. As we only use a small section of Schoenfeld's original instrument it was not possible to carry out a similar analysis but one-way between groups ANOVA with post-hoc comparisons is conducted on all scales in our questionnaire (including the Beliefs about Mathematics Scale) later in this chapter – see Section 6.5. The original analysis of Schoenfeld's scale also examined correlations between students' general academic performance, their perception of their current mathematical performance and their perception of their mathematical ability and these were also correlated with students' responses to other items on the questionnaire. Again, it was difficult to imitate Schoenfeld's original analysis as different scales and measures were used in our study. The following sections on correlations however examine the relationships between all scales used in this study which has some similarity with Schoenfeld's use of correlation.

#### ***Section 6.5: Further Analysis***

In this section we analyse further the 8 scales that make up Section B of the questionnaire. The aim of these 8 scales combined was to assess students' images of mathematics according to our chosen definition. Therefore we need to examine the relationship between the scales and to carry out a more in-depth analysis of the scales

both individually and combined. Earlier in this chapter we looked at the reliability of the individual scales. The Cronbach alpha value was also found for the combined scales as a test of students' image of mathematics. The Cronbach alpha for Image of Mathematics was .94 suggesting a very high internal consistency for the combined scales. The mean score for Image of Mathematics was 288.37 and the standard deviation was 41.15. Next we look at correlations between the scales, a Principal Components Factor Analysis of the scales, Regression Analysis, independent sample t-tests, one-way between groups ANOVA with post-hoc tests and other analyses performed on the data collected.

### **Section 6.5.1: Correlation**

Prior to carrying out correlation analysis, preliminary analyses were performed to ensure no violation of the assumptions of normality, linearity and homoscedasticity (see Pallant, 2010, p.126). Each of the 8 scales was correlated with each other as well as with their combination for image of mathematics. The scales were correlated for all students and also by gender, co-educational status of post-primary school attended, type of post-primary school, Junior Certificate mathematics level and grade and Project Maths pilot school. Table 6.12 shows correlations between scales for all students in the sample. The asterisk signs in the Table 6.12, and all other tables regarding correlations, relate to the significance level of the correlation coefficient. Correlations significant at the 0.05 level have a single asterisk and correlations significant at the 0.01 level have a double asterisk. All correlations between scales were significant except for between the Male Domain scale and the enjoyment, motivation and Self-concept scales. Most of the correlations between scales were found to be significant at the 0.01 level with only two found to be significant at the 0.05 level, namely between the Success scale and the Anxiety scale and between the Male Domain scale and the Anxiety scale. All individual scales correlated significantly with the combination of scales, labelled as "Image of Maths".

Correlations								
		Value	Success	Motivation	Beliefs	Male Domain	Self-Concept	Anxiety
Enjoyment	Pearson Correlation	.591**	.234**	.795**	.316**	.020	.769**	.750**
		Success	Motivation	Beliefs	Male Domain	Self-Concept	Anxiety	Image of Maths
Value	Pearson Correlation	.331**	.501**	.314**	.167**	.458**	.382**	.683**
				Motivation	Beliefs	Male Domain	Self-Concept	Anxiety
Success	Pearson Correlation			.270**	.167**	.304**	.175**	.133*
				Beliefs	Male Domain	Self-Concept	Anxiety	Image of Maths
Motivation	Pearson Correlation			.368**	.091	.666**	.572**	.835**
				Male Domain	Self-Concept	Anxiety	Image of Maths	
Beliefs	Pearson Correlation			.165**	.333**	.250**	.458**	
				Self-Concept	Anxiety	Image of Maths		
Male Domain	Pearson Correlation			-.019	-.113*	.262**		
				Anxiety	Image of Maths			
Self-Concept	Pearson Correlation			.811**	.833**			
				Image of Maths				
Anxiety	Pearson Correlation			.767**				

**Table 6.12: Pearson's Correlations**

Scales were also correlated with each other for males and females. All correlations were significant at either the 0.05 or 0.01 levels except for correlations between the Enjoyment scale and Male Domain scale (males and females); the Success scale and Beliefs scale (males); the Success scale and Anxiety scale (females); the Motivation scale and Male Domain scale (females); the Beliefs scale and Anxiety scale (males); the Male Domain scale and Self-concept scale (males and females); the Male Domain scale and Anxiety scale (males and females). The statistical significance of the difference between correlation coefficients was calculated for males and females and no significant difference was found.

Correlations between scales examined by co-educational status of school attended, type of post-primary school, attendance of a Project Maths pilot school and prior achievement can be found on the attached Appendix CD. The extended version of this chapter on the CD also includes details on the statistically significant differences between correlation coefficients for each of the groups.

### **Section 6.5.2: Partial Correlation**

To further analyse the relationships between scales we also carried out *partial correlation analysis* which allowed us to control for the possible influence of the Student Profile variables. Partial correlation was computed between scales while controlling for the effect of gender, co-educational status of schools, type of post-primary schools, Junior Certificate mathematics level, Junior Certificate mathematics grade and Project Maths pilot schools. Each of these factors was found to have little or no effect on the correlation coefficients. Partial correlations are outlined in more detail on the Appendix CD.

The relationship between the scales was examined by controlling for the effect of each individual scale on the relationships between the other 7 scales. Tables, in the extended version of Chapter 6 on the Appendix CD, show the greatest changes to correlation coefficients when the effect of each scale is controlled for. It was found that students' enjoyment of mathematics has an influence on the relationship between certain scales. In particular, the scales affected by the Enjoyment of Mathematics Scale are the Value of Mathematics Scale, the Effectance Motivation in Mathematics Scale, the Mathematical Self-concept scale and the Anxiety about Mathematics Scale.

Students' value of mathematics was seen to influence correlations between certain scales, chiefly – the Attitude toward Success in Mathematics Scale, the Beliefs about Mathematics Scale, the Mathematical Self-concept scale and the Anxiety about Mathematics Scale. In particular, the Success scale and the Beliefs scale appeared to be affected by the Value of Mathematics Scale in our study.

The Attitude toward Success in Mathematics Scale had little influence on the other scales that are used in our study. The main effect of students' attitudes towards mathematics was felt regarding the Mathematics as a Male Domain scale.

Students' motivation in mathematics was found to be one of the greatest influences on the relationship between the other scales. In particular, the suppression of the Effectance Motivation in Mathematics Scale was found to affect the Enjoyment of Mathematics Scale, the Value of Mathematics Scale, the Mathematical Self-concept scale and the Anxiety about Mathematics Scale but the relationships between most scales were affected to some degree.

The main scales to be effected by the controlling of students' beliefs about mathematics were the Value of Mathematics Scale, the Attitude toward Success in Mathematics Scale and the Mathematics as a Male Domain scale. The influence of the Beliefs about Mathematics Scale on the correlation between scales was quite small when compared to the effect of some of the other scales.

The next variable to be controlled for was with regards to students' beliefs about mathematics as a male domain. The effect of this variable was found to be very small, with few if any noticeable changes to the correlation coefficients.

The effect of students' self-concept on the relationship between scales was most strongly felt in relation to the Enjoyment of Mathematics Scale, the Motivation in Mathematics Scale and the Anxiety about Mathematics Scale. Not surprisingly, the Mathematical Self-concept scale had the greatest influence on the relationships involving the Anxiety scale.

The final variable to be controlled for in the partial correlation of the scales was students' anxiety about mathematics. The influence of students' anxiety about mathematics is most strongly felt with regards to the Enjoyment of Mathematics Scale, the Effectance Motivation in Mathematics Scale and the Mathematical Self-concept scale. The findings suggest that the Anxiety about Mathematics Scale had a clear effect on the relationship between the other scales used for our study.

The findings from the partial correlation indicate that while students' gender, type of post-primary school attended and prior achievement in mathematics have some effect on correlation between scales, the main effect on correlation coefficients was from the scales themselves. In particular, the Enjoyment of Mathematics Scale, the Value of Mathematics Scale, the Effectance Motivation in Mathematics Scale, the Mathematical Self-concept scale and the Anxiety about Mathematics Scale emerged as having a clear influence on the inter-correlation of scales.

### **Section 6.5.3: Principal Components Factor Analysis**

A principal components factor analysis was conducted for each of the 8 scales used for our study, i.e., Enjoyment of Mathematics Scale, Value of Mathematics Scale, Attitude toward Success in Mathematics Scale, Effectance Motivation in Mathematics Scale, Beliefs about Mathematics Scale, Mathematics as a Male Domain scale, Mathematical Self-concept scale and Anxiety about Mathematics Scale. Prior to performing the principal components analysis, the suitability of data for factor analysis was assessed. The sample was deemed sufficient (over 300 cases) and the correlation matrix for each scale was examined revealing many coefficients of .3 and above.

The first scale to be subjected to principal components factor analysis was the Enjoyment of Mathematics Scale (Aiken, 1974). The Kaiser-Meyer-Olkin (KMO) value was found to be .896, above the required .6 (see Kaiser, 1970, 1974) and Bartlett's Test of Sphericity (Bartlett, 1954) reached statistical significance at the 0.01 level, supporting the factorability of the correlation matrix. Principal components analysis revealed two components recording eigenvalues above 1 and explaining 55.33% of the variance. To aid in the interpretation of the two components oblimin rotation was performed. The rotated solution revealed the presence of a simple structure with most items loading substantially on only one component. Negative enjoyment items loaded strongly on Component 1 and positive enjoyment items loaded strongly on Component 2. There was a negative correlation between factors of -0.45.

For the Value of Mathematics Scale (Aiken, 1974), the KMO value was .811 and Bartlett's test reached statistical significance at the 0.01 level. Principal components analysis recorded 3 components with eigenvalues above 1 and explaining 53.3% of the variance. Oblimin rotation reveals 6 items loading strongly on Component 1, 2 items loading strongly on Component 2 and 2 items loading strongly on Component 3. Items loading on Component 1 are mainly positive and refer to the usefulness of mathematics. Items loading on Component 2 deal with mathematics in relation to art and literature. Items loading on Component 3 are negative value of mathematics items. Correlations between the 3-factor solution are weak: 0.24 between Factors 1 and 2, 0.19 between Factors 1 and 3 and 0.05 between Factors 2 and 3.

The Attitude toward Success in Mathematics Scale (Fennema & Sherman, 1976) was found to have a KMO value of .822 and Bartlett's Test was significant at the 0.01 level. A principal component factor analysis revealed 3 components with eigenvalues above 1 and explaining 55.61% of the variance. Oblimin rotation found 6 items loading above .3 on Component 1, 5 items loading above .3 on Component 2 and 5 items loading above .3 on Component 3. Positive attitude toward success items loaded strongly on the first component. For the second component, items were mainly negative and referred to reaction to success in mathematics. Negative attitude toward success items loaded strongly on the third component. A low correlation was found for Factors 1 and 2 (0.11) and Factors 2 and 3 (-0.13) and a slightly higher correlation was found for Factors 1 and 3 (-0.39).

The Effectance Motivation in Mathematics Scale Fennema & Sherman, (1976) had a high KMO value of .907 and Bartlett's test was found to be significant at the 0.01 level. Principal components analysis found two components with eigenvalues above 1 accounting for 50.31% of the variance. Oblimin rotation was performed. 11 items loaded above .3 on Component 1 and 3 items loaded above .3 on Component 2. The majority of the items making up the Motivation scale loaded on Component 1. The two items that loaded strongly on Component 2 were items which may have been misunderstood by students, particularly the item stating *I am*

*challenged by mathematics problems I can't understand immediately.* Students may have been unsure whether this statement was positive or negative. The correlation coefficient between the 2 factors was very low – only 0.09.

The Beliefs about Mathematics Scale (Schoenfeld, 1989) was found to have a low KMO value of .547 which is below the recommended value of .6. The Bartlett's test was significant at the 0.01 level. However, the correlation matrix for the Beliefs scale showed very low correlations between items and so the scale appeared inappropriate for use with principal components factor analysis,

A high KMO value of .903 was found for the Mathematics as a Male Domain scale (Fennema & Sherman, 1976). Bartlett's test also reached significance at the 0.01 level. Two components emerged with eigenvalues above 1 accounting for 50.78% of the variance. Oblimin rotation revealed a simple structure with 8 items loading above .3 on Component 1 and 8 items loading above .3 on Component 2. Negative items loaded strongly on the first component and positive items loaded strongly on the second component. A strong correlation was found between the two factors: 0.41.

For the Mathematical Self-concept scale (Gourgey, 1982), the KMO value was .885 and Bartlett's test reached statistical significance at the 0.01 level. Two components emerged with eigenvalues above 1 and explained 50.32% of the variance. Oblimin rotation revealed a simple structure with most items loading substantially on only one factor. Negative self-concept items loaded strongly on Component 1 and positive self-concept items loaded strongly on Component 2. The correlation between the 2 factors was quite strong at 0.46.

The Anxiety about Mathematics Scale (Fennema & Sherman, 1976) was seen to have a KMO value of .904 and Bartlett's test reached significance at the 0.01 level. The principal components analysis found two components with eigenvalues above 1 and accounting for 51.72% of the variance. Oblimin Rotation was performed and all 12 items were found to load above .3 on Component 1 and 5 items loaded



above .3 on Component 2. For Component 1, 9 of the 12 items loaded strongly, while 3 items loaded more strongly on Component 2. The 2-factor solution appears to set aside 3 items from the remainder of the Anxiety scale. These items were all positive and a positive response to these items would indicate very low anxiety levels in students.

Finally the 8 scales discussed were also subjected to principal components factor analysis as a group as a preliminary analysis of the factorisation of our theoretical image of mathematics scale. A 2-factor solution emerged as 2 components recorded eigenvalues above 1 and accounting for 65.45% of the variance. Oblimin rotation was performed and 6 of the 8 scales loaded above .3 on Component 1 and 4 of the scales loaded above .3 on Component 2. The scales that loaded strongly on the first component and make up Factor 1 are the Enjoyment of Mathematics Scale, Value of Mathematics Scale, Effectance Motivation in Mathematics Scale, Mathematical Self-concept scale, Anxiety about Mathematics Scale and to a lesser extent, the Beliefs about Mathematics Scale. The scales that loaded strongly on the second component and thus make up Factor 2 are the Attitude toward Success in Mathematics Scale and Mathematics as a Male Domain scale. This finding coincides with the findings from partial correlation performed on the data. As reported in the Section 6.5.2, the Enjoyment scale, Value scale, Motivation scale, Self-concept scale and Anxiety scale were found to have a strong relationship, with these scales found to have the greatest influence on inter-correlation of scales. Here they were found to load strongly on one factor suggesting a consistent underlying construct across these scales.

#### **Section 6.5.4: Multiple Regression**

Multiple regression is a family of techniques that can be used to explore the relationship between one continuous dependent variable and a number of independent variables or predictors. A number of assumptions are made about the data in multiple regression analysis, such as sample size (generalizability), multicollinearity and singularity of the independent variables, outliers, normality, linearity,

homoscedasticity and independence of residuals. Care must be taken that none of the assumptions required for multiple regression analysis are violated. Standard multiple regression is the chosen type of multiple regression analysis in our study. Standard multiple regression will be used on each of the 8 scales used in our study. Each of the scales were entered as the dependent variable and the remaining 7 scales as well as some student profile variables were analysed as possible predictors of the dependent variable.

### **Section 6.5.4.1: Enjoyment of Mathematics**

The first scale to be entered as a dependent variable in the standard multiple regression analysis was the Enjoyment of Mathematics Scale. Each of the remaining 7 scales was entered as an independent variable. The students profile variables of gender, co-educational status of post-primary school, type of post-primary school and Junior Certificate mathematics level and grade were considered as possible predictors. Gender and prior achievement in mathematics have been discussed in Chapter 2 on the review of the related literature and were found to have a relationship with students' attitudes towards mathematics and therefore it was deemed appropriate to include gender and Junior Certificate mathematics level and grade as independent variables in the standard multiple regression analysis. (These variables are used in for each scale analysed by multiple regression). As variables used in multiple regression must be either continuous or dichotomous, it was necessary to first regroup Junior Certificate mathematics level and grade into dichotomous variables. Having performed the standard multiple regression analysis for the Enjoyment scale using the independent variables mentioned, it was necessary to first ensure that that our chosen variables did not violate the assumptions of multicollinearity. The Success scale, Male Domain scale, gender and mathematics level and grade variables were all seen to have very low correlation with the Enjoyment scale and therefore immediately were shown to have very little relationship with the dependent variable. Thus the analysis was re-done excluding these predictors. This method was re-iterated for each of the scales. The final model did not violate any of the assumptions for multiple regression and was found to explain 79.8% of the variance in the Enjoyment scale.

The model also reached statistical significance at the 0.01 level. The 5 independent variables included in the model were examined with regards to their contribution to the prediction of enjoyment of mathematics. The standardised beta coefficients (see Pallant, 2010, p.161) were as follows:

- Motivation (0.43)
- Anxiety (0.32)
- Value (0.20)
- Self-Concept (0.14)
- Beliefs (-0.03).

Four of these variables made a statistically significant unique contribution to the prediction of enjoyment of mathematics. The Beliefs scale was not found to make a statistically unique contribution. Therefore our final standard multiple regression model includes the Value of Mathematics Scale, Effectance Motivation in Mathematics Scale, Mathematical Self-concept scale and Anxiety about Mathematics Scale explaining 79.7% of the variance in enjoyment of mathematics. Within the model, motivation in mathematics makes the largest contribution, followed by anxiety about mathematics, value of mathematics and mathematical self-concept.

#### **Section 6.5.4.2: Value of Mathematics**

For the Value of Mathematics Scale, the Male Domain scale, gender and mathematics level and grade variables were eliminated from the multiple regression model due to low correlation values. The remaining 6 scales did not violate any of the assumptions for multiple regression and explained 41% of the variance in value of mathematics, The model also reached statistical significance. The beta coefficients were found to be:

- Enjoyment (0.59)
- Success (0.19)
- Anxiety (-0.17)
- Beliefs (0.12)

- Self-Concept (0.09)
- Motivation (-0.02).

Four of the independent variables were found to be statistically significant at the 0.05 level (we shall write this as  $p < .05$ ) while two variables, the Self-concept scale and the Motivation scale, were not found to make a significantly unique contribution with  $p > .05$ . The final standard multiple regression model includes the Enjoyment of Mathematics Scale, Attitude toward Success in Mathematics Scale, Beliefs about Mathematics Scale and Anxiety about Mathematics Scale and explains 40.8% of the variance in value of mathematics. Within the model, enjoyment of mathematics makes the largest contribution to the prediction of value, followed by attitude toward success in mathematics, beliefs about mathematics and anxiety about mathematics.

#### **Section 6.5.4.3: Attitude toward Success in Mathematics**

The Attitude toward Success in Mathematics Scale was next to be entered as a dependent variable in the standard multiple regression analysis. Due to low correlation with the Success scale, only two of the independent variables remained in the model - the Value scale and Male Domain scale and these were found to explain only 17.3% of the variance in attitude toward success. The model reached statistical significance. The low percentage of variance explained may imply that the attitude toward success in mathematics scale does not fit well with the other scales used for our study. The standardised beta coefficients for the two independent variables were as follows:

- Value (0.29)
- Male Domain (0.26).

Both of these two independent variables were found to make a significantly unique contribution to the prediction of the dependent variable. Thus the final model includes the Value of Mathematics Scale and Mathematics as a Male Domain scale, explaining 17.3% of the variance in attitude toward success in mathematics.

#### **Section 6.5.4.4: Effectance Motivation in Mathematics**

For the Effectance Motivation in Mathematics Scale, the Success scale, Male Domain scale, gender and mathematics level and grade variables were omitted due to low correlation. The remaining 5 scales were included in the model and explained 66.1% of the variance in motivation in mathematics. The model reached statistical significance at the 0.01 level. The beta coefficient values for the variables were:

- Enjoyment (0.72)
- Self-Concept (0.21)
- Anxiety (-0.17)
- Beliefs (0.11)
- Value (0.01).

Four of the five predictors were found to make a significantly unique contribution to the prediction of motivation in mathematics but the Value of Mathematics Scale did not make a significantly unique contribution ( $p > .05$ ). Thus, the final standard multiple regression model includes the Enjoyment of Mathematics Scale, Beliefs about Mathematics Scale, Mathematical Self-concept scale and Anxiety about Mathematics Scale, explaining 66% of the variance in motivation in mathematics.. The greatest contribution to the prediction of motivation was made by enjoyment of mathematics, followed by mathematical self-concept, anxiety about mathematics and beliefs about mathematics.

#### **Section 6.5.4.5: Beliefs about Mathematics Scale**

The Beliefs about Mathematics Scale was next to be entered as a dependent variable in the standard multiple regression analysis. Four independent variables remained in the new model (after examining correlations) which explained 17.2% of the variance in beliefs about mathematics and reached significance. The low value found for percentage of variance explained may indicate that the Beliefs scale does not fit well with the combination of scales used. Also, the Beliefs about Mathematics scale was found to have a very low reliability and therefore findings regarding the

Beliefs scale are to be interpreted cautiously. The standardised beta coefficients were examined for each of the predictors in the model:

- Motivation (0.27)
- Value (0.18)
- Self-Concept (0.18)
- Enjoyment (-0.15).

A significantly unique contribution to the prediction of beliefs was made by the motivation, value and Self-concept scales but not by the Enjoyment scale. The final model included the Value of Mathematics Scale, Effectance Motivation in Mathematics Scale and the Mathematical Self-concept scale and explains 16.6% of the variance in beliefs about mathematics. Motivation in mathematics was found to make the greatest contribution to the prediction of beliefs, followed by value of mathematics and mathematical self-concept.

#### **Section 6.5.4.6: Mathematics as a Male Domain**

The next dependent variable was the Mathematics as a Male Domain scale, From all of the independent variables entered, only two were found to correlate above .3 with the Male Domain scale, namely the Attitude toward Success in Mathematics Scale and gender. With so few variables retained in the model and given the relationship between the Male Domain scale and gender, it was decided to also examine the correlation coefficients between the Mathematics as a Male Domain scale and the co-educational status of post-primary schools attended by students and the type of post-primary school attended. Due to the need for dichotomous variables in multiple regression analysis, the co-educational status and types of post-primary schools were re-grouped into dichotomous variables as follows. The correlation coefficients between these new variables and the Male Domain scale were examined and as a result, one variable – Single-sex Girls – was found to have some relationship with the dependent variable (.353). Thus a new standard multiple regression model was formed for the Mathematics as a Male Domain scale with the independent

variables consisting of the Success scale, gender and single-sex girls' schools. This new model explained 25.1% of the variance in mathematics as a male domain and the model reached statistical significance at the 0.01 level. The following beta coefficients were found:

- Success (0.27)
- Gender (0.25)
- Single-sex Girls' Schools (0.21).

All three of the independent variables were seen to make a significantly unique contribution to the prediction of mathematics as a male domain. Therefore this model was retained with the greatest contribution to the prediction of the Mathematics as a Male Domain scale being attitude toward success in mathematics, followed by gender and the attendance of a single-sex girls' school.

#### **Section 6.5.4.7: Mathematical Self-Concept**

The Mathematical Self-concept scale was entered as a dependent variable in the next standard multiple regression analysis. The Success scale, Male Domain scale, gender and mathematics level and grade variables were omitted due to low correlation with the dependent variable. The new model consisting of the remaining 5 scales explained 73.4% of the variance in self-concept and reached statistical significance at the 0.01 level. The standardised beta coefficients for each of the 5 predictors were found as follows:

- Anxiety (0.55)
- Enjoyment (0.19)
- Motivation (0.16)
- Beliefs (0.07)
- Value (0.04).

The Value of Mathematics Scale was not found to make a significantly unique contribution and so the final standard multiple regression model for mathematical

self-concept was made up of the Enjoyment of Mathematics Scale, Effectance Motivation in Mathematics Scale, Beliefs about Mathematics Scale and Anxiety about Mathematics Scale. Anxiety about mathematics was found to be the greatest contribution to the prediction of mathematical self-concept, followed (not so closely) by enjoyment of mathematics, motivation in mathematics and beliefs about mathematics.

#### **Section 6.5.4.8: Anxiety about Mathematics**

The final of the scale to be entered as a dependent variable in the standard multiple regression analysis was the Anxiety about Mathematics Scale. Assessment of correlations resulted in the elimination of the Success scale, Beliefs scale, Male Domain scale and mathematics level and grade variables from the model. As gender was seen to have some relationship with anxiety about mathematics it was decided to also check the correlation coefficients between the dependent variable and the coeducational status of schools. However no correlations above .3 were found. The new standard multiple regression model was set with the remaining 4 scales and gender as the independent variables. This model explained 72.7% of the variance in anxiety about mathematics and reached statistical significance at the 0.01 level. The contribution of the independent variables to the prediction of anxiety about mathematics is shown in the beta coefficients:

- Self-Concept (0.58)
- Enjoyment (0.43)
- Gender (-0.13)
- Motivation (-0.13)
- Value (-0.09).

All five of the independent variables made a significantly unique contribution to the prediction of anxiety about mathematics and thus were included in the final model. The greatest contribution to the prediction of anxiety about mathematics is



mathematical self-concept, followed by enjoyment of mathematics, gender of student, motivation in mathematics and value of mathematics.

#### **Section 6.5.4.9: Image of Mathematics**

The eight scales used in our study have been analysed individually using standard multiple regression but it was deemed appropriate to also examine the combination of these scales as students' images of mathematics in order to further determine the relationship between the scales and to highlight predictors for obtaining an image of mathematics. Thus image of mathematics was entered as a dependent variable with the eight scales set as independent variables. Gender and the Junior Certificate mathematics level and grade variables were also entered as possible predictors, as were the co-educational status and types of post-primary school variables. The image of mathematics model was examined under the assumptions for multiple regression and the independent variables with correlation of less than .3 with the dependent variable were eliminated. The independent variables remaining in the standard multiple regression model for image of mathematics included the Enjoyment scale, Value scale, Success scale, Motivation scale, Beliefs scale, Self-concept scale and Anxiety scale. This model satisfied all the assumptions for multiple regression and explained 97.4% of the variance in images of mathematics. The model reached statistical significance. Each of the seven independent variables was assessed in terms of their contribution to the prediction of image of mathematics with the following standardised beta coefficients found:

- Success (0.24)
- Motivation (0.23)
- Enjoyment (0.23)
- Self-Concept (0.22)
- Anxiety (0.17)
- Value (0.16)
- Beliefs (0.10).

As all of the independent variables were observed to make a significantly unique contribution to the prediction of image of mathematics, they were all retained as a model for image of mathematics. Thus the final standard multiple regression model for image of mathematics consists of the Enjoyment of Mathematics Scale, Value of Mathematics Scale, Attitude toward Success in Mathematics Scale, Effectance Motivation in Mathematics Scale, Beliefs about Mathematics Scale, Mathematical Self-concept scale and the Anxiety about Mathematics Scale. The greatest contribution to the prediction of image of mathematics was found to be attitude toward success in mathematics, followed very closely by motivation in mathematics, enjoyment of mathematics, mathematical self-concept, anxiety about mathematics, value of mathematics and finally beliefs about mathematics.

Thus our final model suggests that of the 8 scales adopted in our study as an assessment of students' images of mathematics, 7 can be used as a prediction of students' images of mathematics. The use of standard multiple regression analysis in our study sets the Mathematics as a Male Domain scale apart from the other scales and appears to relate less to the overall concept of image of mathematics than do the other scales.

### **Section 6.5.5: Analysis of Differences between Groups**

There are many different statistical techniques for comparing groups in a data set. Some of these techniques were applied in the analysis of the various groups of students comprised in our sample. From the literature review in Chapter 2, we observed that differences in students' images of mathematics may occur in terms of gender, achievement in mathematics and the co-educational status of school attended. These groups can be seen in our sample of 5<sup>th</sup>-year post-primary students and therefore it was deemed appropriate to compare these groups of students. To further analyse possible significant differences between groups of students in our study, we also group students according to type of post-primary school attended and attendance of a Project Maths pilot school. Thus the groups for comparison in our study are:

- Gender – Males/Females
- Co-Educational Status – Single-sex Boys/Single-sex Girls/Co-Ed
- Type of Post-Primary School – Secondary/Vocational/C+C/Fee-paying
- Project Maths Pilot School – Yes/No
- Junior Certificate Mathematics Level – Higher/Ordinary/Foundation
- Junior Certificate Mathematics Grade – A/B/C/Other

The Mann-Whitney U Test is a technique used to test for differences between two independent groups on a continuous measure. Thus it can be used to compare differences between two groups with regards to the scales included in the questionnaire survey for our study. Differences between groups can be examined regarding their enjoyment of mathematics, value of mathematics, attitude toward success in mathematics, motivation in mathematics, beliefs about mathematics, perception of mathematics as a male domain, mathematical self-concept, anxiety about mathematics and indeed their overall image of mathematics (combination of the 8 scales). For the Mann-Whitney U Test, only two groups can be tested at a time, e.g., males/females and therefore each group of students was re-grouped as dichotomous variables as they had been in the section on multiple regression analysis. The findings from the Mann-Whitney U Test are discussed in terms of effect size according to the criteria of Cohen (1988) with .1=small effect, .3=medium effect and .5=large effect.

The first group to be subjected to the Mann-Whitney U Test was males/females in order to discover the effect of gender in terms of scores given on the scales. The test found a significant difference between males and females for 6 of the scales as well as for overall image of mathematics with effect sizes displayed in Table 6.13. The most significant difference between males and females for our study can be seen in their perception of mathematics as a male domain and in their anxiety about mathematics. The latter finding is consistent with findings in previous research studies (see Chapter 2, Section 2.5.2).

<b>Scale</b>	<b>Males: Median(N)</b>	<b>Females: Median(N)</b>	<b>Effect Size</b>
Enjoyment of Mathematics	34(151)	29(191)	$r=.21$ (small)
Value of Mathematics	36(152)	35(191)	$r=.11$ (small)
Effectance Motivation in Mathematics	36(146)	33(184)	$r=.13$ (small)
Mathematics as a Male Domain	46(150)	53(191)	$r=.38$ (medium)
Mathematical Self-Concept	38(146)	34.5(190)	$r=.18$ (small)
Anxiety about Mathematics	40(147)	34(188)	$r=.30$ (medium)
Image of Mathematics	297(133)	276.5(174)	$r=.14$ (small)

**Table 6.13: Mann-Whitney U Test - Gender**

The next dichotomous group to be compared on the scales was single-sex boys' schools and other schools (single-sex girls and co-educational). A significant difference was found for single-sex boys' schools compared to other schools for the Mathematics as a Male Domain scale only: Single-sex boys - 45(40), Other – 50(291),  $r=.22$ (small effect). For single-sex girls' schools compared to the other schools (single-sex boys and co-educational), a significant difference was found on 4 of the 8 scales with findings outlined in Table 6.14.

<b>Scale</b>	<b>Single-sex Girls: Median(N)</b>	<b>Other: Median(N)</b>	<b>Effect Size</b>
Enjoyment of Mathematics	29(90)	32(252)	.12(small)
Mathematics as a Male Domain	55(90)	48(251)	.37(medium)
Mathematical Self-Concept	34(90)	37(246)	.13(small)
Anxiety about Mathematics	31(89)	37(246)	.23(small)

**Table 6.14: Mann-Whitney U Test - Single-sex Girls' Schools**

The most significant difference found between single-sex girls' schools and other schools was regarding perception of mathematics as a male domain but girls' schools were also seen to score lower on the enjoyment, self-concept and Anxiety scale. For the final dichotomous group in the co-educational status of schools category, co-educational schools were compared to single-sex schools (both boys and girls). A significant difference at the 0.05 level was found in terms of the Mathematics as a Male Domain scale and the Anxiety about Mathematics Scale:

- Male Domain: Co-Ed – 48(201), Other – 52(140),  $r=.17$  (small effect)
- Anxiety: Co-Ed – 37(198), Other – 34(137),  $r=.16$  (small effect).

In terms of the co-educational status of schools attended by students in our sample, a consistent significant difference occurred for the Mathematics as a Male Domain scale with single-sex girls' schools having the highest median and single-sex boys' schools the lowest. Students attending single-sex girls' schools also were found to be significantly different to other students in the sample in terms of their enjoyment of mathematics, mathematical self-concept and anxiety about mathematics with lower median scores recorded for each of these scales by students attending single-sex girls' schools. This is similar to the findings by Badger (1981) in which girls attending co-educational schools had more positive attitudes to mathematics than girls attending single-sex schools.

The next category from the student profile variables to be examined by the Mann-Whitney U Test was the type of post-primary school attended by students in our sample. Although a number of statistically significant differences were found between the post-primary school categories regarding the scales used in the questionnaire, the effect of these differences was small in all cases. Vocational schools were found to have the most differences compared to other school types. See the extended version of Chapter 6 on the Appendix CD for more details.

Differences between students who attended Project Maths pilot schools and students who had not, were also examined using the Mann-Whitney U Test. A small

significant difference was found for only one of the 8 scales used – the Attitude toward Success in Mathematics Scale. The median score for the Project Maths pilot school students was 49(N=48) while the median score for other students was 48(N=292). The effect size for this difference was small ( $r=.11$ ). No other differences were found with regards to students who had taken part in the piloting of Project Maths.

Next the Mann-Whitney U Test was applied to students' prior achievement in mathematics by looking at Junior Certificate mathematics levels and grades. The students were grouped according to both level and grade i.e. higher level Grade A, ordinary level Grade B etc. The first dichotomous group compared students who had received a higher level Grade A with all other students. Significant differences were found regarding students' enjoyment of mathematics, value of mathematics, motivation in mathematics and mathematical self-concept. Findings are displayed in Table 6.15.

<b>Scale</b>	<b>HL-A: Median(N)</b>	<b>Other: Median(N)</b>	<b>Effect Size</b>
Enjoyment of Mathematics	43(8)	30(331)	.15(small)
Value of Mathematics	42(8)	35(332)	.18(small)
Effectance Motivation in Mathematics	47(7)	34(320)	.19(small)
Mathematical Self-Concept	42.5(8)	36(325)	.11(small)
Image of Mathematics	346(5)	285(299)	.18(small)

**Table 6.15: Mann-Whitney U Test - Higher Level Grade A with Others**

Although the effect size found was small in each case, students who received a higher level Grade A for mathematics in the Junior Certificate were found to have significantly higher medians for the enjoyment, value, motivation and Self-concept scales. A significant difference was also found regarding students' overall image of mathematics. The next group to be examined was for higher level Grade B/other with a small but significant difference found for the Value scale, Beliefs scale and Male

Domain. Students who received a higher level Grade B in the Junior Certificate mathematics exam recorded a higher median for each of these scales compared to other students. The next two groups within the prior achievement category – higher level Grade C/other and higher level other grade/others – were found to have no significant differences.

The Mann-Whitney U Test found significant differences for students who received an ordinary level Grade A compared to others with regards to attitude toward success in mathematics and mathematical self-concept. Students with an Ordinary Level Grade A show a slightly more positive attitude toward success in mathematics and higher self-concept of ability in mathematics. The next dichotomous group to be observed was the ordinary level Grade B students/other students with significant differences for this group found for the Enjoyment scale, Self-concept scale and Anxiety scale. Students with an Ordinary Grade B had higher enjoyment, higher self-concept and lower anxiety compared to other students.

Next to be examined were students who received an ordinary level Grade C in the Junior Certificate mathematics exam. A small significant difference was found in four of the scales as can be seen from Table 6.16. A significant difference also occurred with regards to students' image of mathematics as a whole.

<b>Scale</b>	<b>OL-C: Median(N)</b>	<b>Other: Median(N)</b>	<b>Effect Size</b>
Value of Mathematics	33(82)	36(257)	.20(small)
Beliefs about Mathematics	18(81)	19(252)	.14(small)
Mathematics as a Male Domain scale	48(83)	50(254)	.11(small)
Mathematical Self-Concept	34(81)	37(251)	.18(small)
Image of Mathematics	276(73)	289.5(230)	.13(small)

**Table 6.16: Mann-Whitney U Test - Ordinary Level Grade C with Others**

As the second lowest prior achievement grouping, it is not unsurprising to see that ordinary level Grade C students were found to have a significantly lower value of

mathematics, less positive beliefs about mathematics and perception of mathematics as a male domain, lower mathematical self-concept and an overall less positive image of mathematics compared to other students. The effect of these differences was small in all cases. The final group to be examined was the lowest achievement grouping – ordinary level Other (students received lower than a grade C at ordinary level). The Mann-Whitney U Test found that this group had significantly lower enjoyment of mathematics and lower self-concept of ability in mathematics compared with other students. The ‘ordinary level Other’ students also had a significantly lower score on the image of mathematics combination scale compared to other students.

With regards to the prior achievement in mathematics groups, significant differences occurred, with a small effect size found in each case. The most differences were found for the higher achievement groups (students receiving Grade A or B) and for the lowest achievement groups – particularly the ordinary level Grade C and ordinary level Other grade students. These findings from the Mann-Whitney U Test analysis are consistent with previous research on achievement and attitudes, beliefs, motivation, self-concept and anxiety in mathematics (see Brassell et al., 1980; Oldham, 2005; Stevenson & Newman, 1986).

### **Section 6.5.6: Independent Samples T-Test and One-Way Between-Groups ANOVA**

In addition to the non-parametric statistical tests carried out on the data – chi-square test for independence (see Appendix CD) and Mann-Whitney U Test – comparisons between groups were also performed using parametric tests, both independent samples t-tests and one-way between-groups ANOVA. For parametric techniques, a number of assumptions must be met in order to apply the techniques to the data. Firstly, each parametric approach assumes that the dependent variable is measured at the interval or ratio level using a continuous scale rather than discrete categories. Secondly, it is assumed that the scores are obtained using a random sample from the population. Thirdly, the observations that make up your data must be independent of one another; that is, each observation must not be influenced by any other observation. This assumption in particular can cause serious problems if



violated. Students who took part in our study completed the questionnaire independently and did not work together in pairs or groups and therefore responses are their own and not the combined response of more than one student. Although there was a concern that students attending the same school may be influenced to give similar responses, the non-parametric tests performed in the previous section, Section 6.5, did not find that the type of post-primary school attended or co-educational status of the school had any large effect on students' responses in the scales and therefore we can reasonably presume that the assumption of independence of observations has not been violated to any great degree in our sample. The fourth assumption required for parametric techniques is that the population from which the sample is taken is normally distributed. With large samples (e.g. 30+) the violation of this assumption should not cause any major problem. The final assumption made by parametric statistics is homogeneity of variance which requires that variance of scores for each of the groups is similar. As part of both the t-test and ANOVA analyses, Levene's test for equality of variance is performed. While ANOVA (analysis of variance) is reasonably robust to violations of this assumption providing that the size of the groups is reasonably similar, the t-tests provide results for when the assumption is met and for when it is violated. Although there is some disagreement among researchers regarding the use of parametric statistical tests for analysing Likert scales (see Section 4.3.2.1), the data used for our study appears to adhere reasonably well to the assumptions for the use of parametric technique and many researchers have used parametric statistical techniques to analyse the Likert scales used in our study. Also, the non-parametric statistical tests already carried out on the data in Section 6.5.5 will provide a basis for comparing findings from the parametric statistical tests.

### **Section 6.5.6.1: Independent Samples t-test**

Independent samples t-test are used to compare the mean scores of two different groups of people or conditions. For our study it will be used to compare the mean scores of males and females and the mean scores of students attending Project Maths pilot schools and students who do not attend pilot schools. The first groups to be compared using the independent samples t-test were males and females scores on

the 8 individual ‘image of mathematics’ scales as well as the combined image of maths scale. Means, standard deviations, significance of difference between groups and effect size by means of the eta squared formula are provided for the gender groups for each of the scales in Table 6.17.

Scale	Males: Mean(SD)	Females: Mean(SD)	Sig.	Eta squared
Enjoyment	33.07(8.73)	29.50(8.84)	.00	.04
Value	36.00(6.49)	34.71(5.95)	.06	.01
Success	46.46(7.14)	47.79(6.87)	.08	.01
Motivation	36.03(8.53)	34.02(8.86)	.04	.01
Beliefs	19.31(2.85)	19.05(3.10)	.42	.002
Male Domain	44.93(9.44)	51.52(6.46)	.00	.14
Self-Concept	37.75(7.95)	34.39(9.28)	.00	.04
Anxiety	38.69(8.07)	33.13(9.21)	.00	.09
Image of Maths	293.98(40.32)	284.09(41.37)	.04	.01

**Table 6.17: Independent Samples T-Test - Gender**

The independent samples t-test revealed that a significant difference occurred in scores for males and females for the enjoyment, motivation, male domain, self-concept and Anxiety scales as well as for image of mathematics as a whole. For enjoyment, motivation, self-concept and image of mathematics the effect size was small but the effect size for the Male Domain scale was large with gender explaining 14% of the variance in perception of mathematics as a male domain. For the Anxiety scale the effect size was moderate as gender explained 9% of the variance in anxiety about mathematics.

The independent samples t-test was also used to compare mean scores for students who attended or did not attend Project Maths pilot schools. The independent samples t-test found a significant difference for mean scores on only one of the scales, the Attitude toward Success in Mathematics Scale. The effect size was small explaining only 1% of the variance in attitudes toward mathematical success. For the remaining scales, the eta squared value was extremely small and in some cases no

real effect was found. The independent samples t-test indicates that there is very little difference between students who had and had not studied Project Maths throughout post-primary school.

### **Section 6.5.6.2: ANOVA**

Differences between the remaining groups of students were examined using analysis of variance by means of one-way between-groups ANOVA with post-hoc tests. This parametric technique is used when you have one independent variable with three or more levels or groups and one dependent continuous variable. The independent variables examined using ANOVA are the co-educational status of schools, the types of post-primary school, the Junior Certificate mathematics level and Junior Certificate mathematics grade. One-way ANOVA identifies any significant differences in the mean scores across the groups of students and post-hoc tests can then be used to find out where these differences lie. Post-hoc tests are outlined in the Appendix CD version of Chapter 6.

The first independent variable examined was the co-educational status of schools attended by students – single-sex boys' schools, single-sex girls' schools and co-educational or mixed schools. Levene's test for homogeneity of variances was performed for each of the 8 scales as well as image of mathematics as a whole. For co-educational status of schools, the Motivation, Male Domain and Self-concept scales violated the assumption of homogeneity of variances and therefore it is recommended by Pallant (2010) to use Welch and Brown-Forsythe tests of equality of means for these 3 scales. The one-way ANOVA found a statistically significant difference at the  $p < .05$  level in male domain, self-concept and anxiety scores for the co-educational status groups. The statistically significant findings are displayed in Table 6.18.

Scale	Difference	Sig.	Eta-squared
Male Domain	$F(2, 338) = 28.2$	.00	.14
Self-Concept	$F(2, 333) = 3.6$	.03	.02
Anxiety	$F(2, 332) = 9.1$	.00	.05

**Table 6.18: One-Way Between-Groups ANOVA - Co-educational Status**

The eta-squared value for the Mathematics as a Male Domain scale is large indicating that 14% of the variance in perception of mathematics as a male domain is due to co-educational status of schools. The eta-squared values for the Mathematical Self-concept scale and the Anxiety about Mathematics Scale were small with co-educational status explaining 2% of the variance in self-concept and 5% of the variance in anxiety.

The next independent variable examined using one-way between-groups ANOVA was type of post-primary school with students separated into secondary schools, vocational schools, C+C schools and fee-paying schools. The Beliefs about Mathematics Scale violated the assumption of homogeneity of variances and therefore Welch and Brown-Forsyth's tests of equality of means are used for this scale. The analysis of variance found a statistically significant difference at the  $p < .05$  level for the enjoyment, success, male domain and Anxiety scales for the 4 different school types. The significant findings from the one-way ANOVA as well as effect sizes are displayed in Table 6.19.

Scale	Difference	Sig.	Eta-squared
Enjoyment	$F(3, 338) = 4.8$	.00	.04
Success	$F(3, 336) = 3.0$	.03	.03
Male Domain	$F(3, 337) = 3.2$	.02	.03
Anxiety	$F(3, 331) = 2.8$	.04	.02

**Table 6.19: One-Way Between-Groups ANOVA - Type of Post-Primary School**

The effect size for the each of the scales was small. The post-hoc comparison tests performed (see Appendix CD) showed that the majority of significant differences found were between vocational schools and fee-paying schools.

In order to analyse the effect of prior achievement on students' image of mathematics, the Junior Certificate mathematics grades were assessed according to mathematics level using a split-file comparison. The number of students studying foundation level was very small and therefore not conducive to ANOVA analysis. For higher level mathematics students, a medium effect size was found for the Enjoyment and Motivation scales, with the higher level mathematics grades explaining 11% of the variance in enjoyment and 12% of the variance in motivation. For the Value scale and the image of mathematics combination the effect size was large with the higher level mathematics grades explaining 14% of the variance in value and 14% of the variance in students' images of mathematics. Students who received a higher level grade A in mathematics for the Junior Certificate had the highest enjoyment of mathematics, value of mathematics, motivation in mathematics and most positive image of mathematics.

For ordinary level mathematics students, a small effect size was found for the enjoyment, value, success and Anxiety scales, with ordinary level mathematics grades explaining 4% of the variance in enjoyment, 5% of the variance in value, 4% of the variance in attitude to success and 5% of the variance in anxiety. A medium effect size emerged for the Self-concept scale and for image of mathematics with ordinary level mathematics grade explaining 9% of the variance in self-concept and 7% of the variance in image of mathematics. The post-hoc tests carried out revealed that the majority of statistically significant differences emerged between the higher grades (A and B) and the lower grades (C and Other). For the most part, the lowest achievement students (excluding the foundation level students) namely the ordinary level grade Other students, were seen to have the lowest mean scores on the scales.

The parametric statistical techniques applied to the data collected in our study revealed further differences between students in terms of gender, co-educational status of school attended, type of post-primary school attended, attendance of a Project Maths pilot school, and prior achievement in mathematics. The independent samples t-tests and one-way between-groups ANOVA together with the post-hoc tests found that the most significant differences occurred with regards to gender and

prior achievement in mathematics with the effect size statistics disclosing moderate and large values within these student groups. These findings are consistent with previous research studies showing that gender and prior achievement can have an effect of students' attitudes, beliefs, motivation, self-concept and anxiety regarding mathematics and therefore affecting these students' images of mathematics.

### **Section 6.6: Summary**

In this section, we present a summary of the main findings from the analysis of the quantitative data. The findings are displayed in Table 6.20 with the statistical technique employed and the main findings resulting from the analysis. The findings shown in the summary table are those that hold significance for the discussion of findings chapter – Chapter 8. The findings also demonstrate a connection between findings from the various statistical techniques used to analyse the quantitative data in Chapter 6. As Table 6.20 is merely a summary, not all findings can be displayed. However, a thorough discussion of the findings from both this chapter (Chapter 6) and the following Chapter 7 (analysis of the qualitative data) will be provided in Chapter 8.

<b>Method of Analysis</b>	<b>Main Findings</b>
Frequency Distribution of Junior Cert Maths Level:	<ul style="list-style-type: none"> <li>• 95 students (26.7%) studied Higher Level Maths</li> <li>• 30 students received Higher Level Grade A or B.</li> </ul>
Mean Scores for Scales and Scale Items:	<ul style="list-style-type: none"> <li>• Low Enjoyment of Mathematics</li> <li>• Positive Value of Mathematics</li> <li>• Positive Attitude toward Success in Mathematics</li> <li>• Low Motivation in Mathematics</li> <li>• Unsure regarding Beliefs about Mathematics</li> <li>• Positive Perception of Mathematics as both a Male and Female Domain</li> <li>• High Variance in Mathematical Self-Concept</li> <li>• High Variance in Anxiety about Mathematics.</li> </ul>

Cronbach's Alpha:	<ul style="list-style-type: none"> <li>• Low reliability found for Schoenfeld's (1989) Beliefs about Mathematics Scale (0.21).</li> <li>• High reliability found for all other scales and for the 8 scales combined.</li> </ul>
Correlations	<ul style="list-style-type: none"> <li>• Majority of scales correlated significantly with each other at the 0.01 level</li> <li>• No significant correlation found between: Enjoyment of Mathematics Scale and Mathematics as a Male Domain scale; Effectance Motivation in Mathematics Scale and Mathematics as a Male Domain scale; Mathematical Self-concept scale and Mathematics as a Male Domain scale.</li> </ul>
Partial Correlation	<ul style="list-style-type: none"> <li>• Main influence on the inter-correlation of scales was from the Enjoyment of Mathematics Scale, Value of Mathematics Scale, Effectance Motivation in Mathematics Scale, Mathematical Self-concept scale and Anxiety about Mathematics Scale.</li> <li>• Some effect found on inter-correlations from students' gender, type of post-primary school attended and prior achievement in mathematics.</li> </ul>
Principal Components Factor Analysis	<ul style="list-style-type: none"> <li>• Beliefs about Mathematics Scale could not be factorised</li> <li>• Image of Mathematics (scales combined) was found to have a 2-factor solution. Factor 1 was made up of the Enjoyment of Mathematics Scale, Value of Mathematics Scale, Effectance Motivation in Mathematics Scale, Mathematical Self-concept scale, Anxiety about Mathematics Scale and to a lesser extent Beliefs about Mathematics Scale. Factor 2 was made up of the Attitude</li> </ul>

	toward Success in Mathematics Scale and Mathematics as a Male Domain scale.
Multiple Regression	<ul style="list-style-type: none"> <li>• Gender was found to have a strong relationship with the Mathematics as a Male Domain scale and the Anxiety about Mathematics Scale.</li> <li>• Strong relationship found between students' enjoyment, value, motivation, beliefs, self-concept and anxiety regarding mathematics.</li> <li>• The regression model for image of mathematics (scales combined) sets the Mathematics as a Male Domain scale apart from the other 7 scales. The 7 scales explain 97.4% of the variance in students' image of mathematics.</li> </ul>
Mann-Whitney U Test	<ul style="list-style-type: none"> <li>• Gender: Significant difference found in terms of enjoyment, value, motivation, mathematics as a male domain, self-concept, anxiety and over-all image of mathematics.</li> <li>• Co-educational Status: Significant difference found for all school types regarding Mathematics as a Male Domain scale. Majority of differences occurred for single-sex girls' schools compared to other school types with significant differences found regarding enjoyment, mathematics as a male domain, self-concept and anxiety.</li> <li>• Type of Post-primary School: Vocational schools had the most differences compared to other types of post-primary school with vocational school students found to have higher enjoyment, more motivation, higher self-concept and lower anxiety regarding mathematics.</li> <li>• Project Maths: Only significant</li> </ul>



	<p>difference found was for the Attitude toward Success in Mathematics Scale with students attending a Project Maths pilot school having a slightly more positive attitude toward mathematical success.</p> <ul style="list-style-type: none"> <li>• Prior Achievement: Higher Level Grade A students were found to have significantly higher enjoyment, value, motivation and self-concept in mathematics as well as the most positive overall image of mathematics compared to other achievement groups. Ordinary Level Grade C students were found to have lower median scores for value, beliefs, mathematics as a male domain, self-concept and image of mathematics. Ordinary Level Other had lower enjoyment of maths, self-concept of maths and more negative image of mathematics.</li> </ul>
Independent Samples t-test	<ul style="list-style-type: none"> <li>• Gender: Significant difference for the enjoyment, value, success, motivation, beliefs, male domain, self-concept and Anxiety scales as well as for image of mathematics combined. Greatest effect found for male domain and Anxiety scales.</li> <li>• Project Maths: Significant Difference found for Attitude toward Success in Mathematics Scale but with only a small effect.</li> </ul>
ANOVA	<ul style="list-style-type: none"> <li>• Co-educational Status: A significant difference was found for the male domain, self-concept and Anxiety scales.</li> <li>• Type of Post-primary School: A significant difference was found regarding students' enjoyment, attitude toward success, perception of mathematics as a</li> </ul>

	<p>male domain and anxiety in mathematics. The majority of differences occurred between vocational and fee-paying schools.</p> <ul style="list-style-type: none"> <li>• Prior Achievement: Main significant differences occur between the highest achievement (Higher Level Grades A and B) and lowest achievement (Ordinary Level Grade Other).</li> </ul>
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**Table 6.20: Summary of Findings from Qualitative Data**

## **Chapter Seven**

### **A Further Look at Students' Images of Mathematics: Analysis of the Qualitative Data**

## **Chapter Seven: A Further Look at Students' Image of Mathematics: Analysis of the Qualitative Data**

In this chapter we examine the questionnaire items that contain open-ended questions and therefore are qualitative items requiring separate attention from the fixed-response quantitative questions/items in Chapter 6. The first item to be examined in this chapter is part of the Student Profile section of the questionnaire survey and relates to students' parents' occupations. All other questions explored in this chapter are from Section A of the questionnaire – the open-ended questions regarding students past experiences of mathematics, students' interest/disinterest in mathematics, the possible influences on students' image of mathematics, students' causal attributions for success/failure in mathematics and students' perceptions of the usefulness of mathematics in everyday life. The responses given by students to the qualitative questions are categorised and analysed as such on SPSS. The constant comparative method is used to analyse and categorise open-ended questions. The constant comparative method *“combines systematic data collection, coding, and analysis with theoretical sampling in order to generate theory that is integrated, close to the data, and expressed in a form clear enough for further testing”* (Conrad et al., 1993, p.280). The responses to the open-ended questions are sorted into categories and then integrated into broader categories to be analyzed and coded. In addition, individual responses are also examined qualitatively, bearing in mind previous research findings on related issues as discussed in the literature review of Chapter 2.

### **Section 7.1 Parents' Occupation**

In the Student Profile section of the questionnaire students were asked about their parent(s)' occupation. As part of the requirements for ethical approval of our study, this item was stressed as optional in the questionnaire, and students were advised that they did not have to answer this question. As a result, this item received the lowest response rate out of the entire questionnaire with just over half of students providing an answer. As the item on parents' occupations was open-ended, there were numerous responses given, too many and too diverse to categorise each individual

response and therefore occupations were grouped similarly to Lim (1999) in her study on the public image of mathematics. In her study, occupations were classified as:

1. Professional
2. Managerial and Technical
3. Skilled (both manual and non manual)
4. Unskilled and partially skilled
5. Others (unemployed, retired and unclassifiable occupations).

Lim's classifications were used as a basis for categorising parents' occupations in our study. The categories for Parents' Occupation in our study are Professional; Technical and Managerial; Skilled; Unskilled and partially skilled; Mathematics; and Others. In cases where occupations for both parents had been given, the first occupation was selected. The variables for parent(s)' occupation was correlated with the other student profile variables with correlations shown in Table 7.1.

Correlations							
		Gender of Student	Post-primary School Attending	Junior Certificate Mathematics Level	Junior Certificate Mathematics Grade	School Type/Category	Project Maths
Parents' Occupation with Groups Collapsed	Pearson Correlation	.124*	.006	-.086	-.022	-.129*	.017
	Sig. (2-tailed)	.019	.908	.107	.677	.015	.750
	N	356	356	353	350	356	356
*. Correlation is significant at the 0.05 level (2-tailed).							

**Table 7.1: Correlations for Parent(s)' Occupation with Student Profile Variables**

A significant correlation was found between parent(s)' occupation and gender and between parent(s)' occupation and type of post-primary school attended by students, both significant at the .05 level. The relationship between parents' occupation and the type of post-primary school attended is explored further in an extended version of this chapter on the Appendix CD.

Parent(s)' occupation was examined with regards to students' enjoyment of mathematics, value of mathematics, attitude toward success in mathematics, motivation in mathematics, beliefs about mathematics, perception of mathematics as a male domain, mathematical self-concept, anxiety about mathematics and finally, students' overall image of mathematics. Findings for students who provided their parent's occupation are compared with those for students who did not provide their parents' occupations. Boxplots for each of the scales are provided on the Appendix CD.

As a result of the analysis of parent(s)' occupation and the image of mathematics scales (both individual scales and the combination of scales), a statistically significant relationship was found between students' parents' occupations and students attitude toward success in mathematics, and also between students' parents' occupations and students' perception of mathematics as a male domain. The most significant finding however, may be with regards to students whose parents are involved in mathematics in their occupations. For most of the scales, and also for the combination of the scales, the Mathematics category of parent(s)' occupation showed the highest median scores and, in some situations, was set apart considerably from the other categories. Students with parents in the Mathematics classification of occupations were seen to have the highest enjoyment of mathematics, the highest value of mathematics, the most positive attitude towards success in mathematics, a high motivation regarding mathematics, the most positive perception of mathematics as a domain for both males and females, the highest mathematical self-concept, the lowest anxiety levels with regards to mathematics and overall, the most positive image of mathematics. Due to the small number of students with parents involved in mathematics based careers, these findings cannot be taken as conclusive and indeed further research would be necessary to clarify the findings from the analysis in our study.

## Section 7.2: Question 1

In Question 1 of the qualitative section of the questionnaire – Section A – students were asked about their earliest memories of studying mathematics. The responses to this open-ended question were categorised in order to analyse responses on SPSS. More details of the response categories can be seen on the Appendix CD version on Chapter 7. Frequencies of responses for the categories are provided in Table 7.2.

Category		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	1 Primary School	111	31.2	32.0	32.0
	2 School Abroad	9	2.5	2.6	34.6
	3 Learning to Count	27	7.6	7.8	42.4
	4 Add/Sub/Multiply/Divide	63	17.7	18.2	60.5
	5 Maths Difficult	15	4.2	4.3	64.8
	6 Multiplication Tables	51	14.3	14.7	79.5
	7 Post-primary School	6	1.7	1.7	81.3
	8 Negative Experience with Teacher	9	2.6	2.6	83.9
	9 Competition	5	1.4	1.4	85.3
	10 Help from Family	10	2.8	2.9	88.2
	11 Maths Games	10	2.8	2.9	91.1
	12 Specific Type of Maths	14	3.9	4.0	95.1
	13 Maths Book	4	1.1	1.2	96.3
	14 Other	13	3.7	3.7	100.0
	Total	347	97.5	100.0	
Missing	0 No Answer	9	2.5		
Total		356	100.0		

**Table 7.2: Section A: Question 1 - Frequency**

The response rate for Section A Question 1 was high, with 347 students (97.5%) answering this question. Only 9 students gave no answer to this question. The most frequent response category was Primary School (111 students, 31.2%) and many of the responses given by students in this category gave no further explanation other than stating “primary school”. The large number of students in the Multiplication

Tables category suggests that rote learning played a significant role in students' learning of mathematics. Negative responses to the question on students' earliest memories of mathematics were expressed in 2 categories in particular, namely Maths Difficult and Negative Experience with Teacher. A combined total of 24 students (6.8%) expressed negative memories of studying mathematics from these 2 categories. In order to find out more about the responses given to Question 1, this question was correlated with the student profile variables. A significant correlation was found for Question 1 with gender, parent(s)' occupation and co-educational status of post-primary school. The correlations between Question 1 and gender and between Question 1 and co-educational status were significant at the 0.05 level while the correlation between Question 1 and parent(s)' occupation was significant at the 0.01 level. The relationship between students' responses to Question 1 and students' attitudes, motivation, beliefs, self-concept and anxiety regarding mathematics as well as students' overall image of mathematics was examined by means of Pearson's Correlation. A significant correlation was found for 3 of the 8 scales as well as for students' image of mathematics as a whole. The correlation between Question 1 and the Beliefs about Mathematics Scale was significant at the 0.05 level. The Pearson Correlation values for Question 1 with the Effectance Motivation in Mathematics Scale, the Mathematics as a Male Domain scale and the Image of Mathematics combination scale were statistically significant at the 0.01 level. However, the correlations found for Question 1 with the quantitative scales were all quite low, possibly due to the low number of students in some of the response categories. Thus, it was decided to re-code the categories in Question 1 into broader categories, with frequencies shown in Table 7.3.



Correlations										
		Enjoy	Value	Success	Motivation	Beliefs	Male Domain	Self Concept	Anxiety	Image of Maths
SAQ1-recode	Pearson Correlation	.153**	.178**	.124*	.195**	.169**	.193**	.115*	.043	.212**
	Sig. (2-tailed)	.005	.001	.022	.000	.002	.000	.035	.436	.000
	N	342	343	340	330	337	341	336	335	307
**. Correlation is significant at the 0.01 level (2-tailed). *. Correlation is significant at the 0.05 level (2-tailed).										

**Table 7.3: Pearson's Correlation for Section A Question 1 re-coded with Image of Mathematics Scales**

As can be seen from Table 7.3, with the Question 1 responses re-coded, a statistically significant correlation was found for all scales except for the Anxiety about Mathematics Scale. The Attitude toward Success in Mathematics Scale and the Mathematical Self-concept scale correlated with Question1 (recoded) at the 0.05 level and all other scales correlated at the 0.01 level. The re-coded response categories for Question 1 are examined with regards to gender of students in the extended version of this chapter on the Appendix CD. It was found that twice as many females as males responded to Question 1 in terms of negative memories. The response category Negative Memories also comprised more specific and detailed answers than the other response categories.

Section A Question 1 (the re-coded version) was further examined in relation to the image of mathematics scales, both the 8 individual scales as well as the combined scales. The median score for students in each of the response categories with respect to the image of mathematics scales are displayed in Table 7.4. The total possible score for each scale is indicated in brackets beside each scale, i.e. Enjoyment of Mathematics (55). The total possible score for Image of Maths is obtained by adding total scores for each of the 8 scales.

Scale	School	Learning Mathematics	Negative Memories	Positive Memories
Enjoyment of Mathematics (55)	30.0	31.0	<b><i>27.0</i></b>	<b><u>40.0</u></b>
Value of Mathematics (50)	34.5	36.0	<b><i>34.0</i></b>	<b><u>39.0</u></b>
Attitude toward Success in Mathematics (60)	47.0	48.0	<b><i>44.0</i></b>	<b><u>52.0</u></b>
Effectance Motivation in Mathematics (60)	<b><i>33.0</i></b>	35.0	33.5	<b><u>41.0</u></b>
Beliefs about Mathematics (30)	<b><i>18.0</i></b>	20.0	19.0	<b><u>20.0</u></b>
Mathematics as a Male Domain (60)	<b><i>48.0</i></b>	50.0	54.0	<b><u>55.0</u></b>
Mathematical Self-Concept (60)	36.0	37.0	<b><i>28.0</i></b>	<b><u>42.5</u></b>
Anxiety about Mathematics (60)	36.0	36.0	<b><i>28.0</i></b>	<b><u>42.5</u></b>
Image of Mathematics (381)	276.0	291.0	<b><i>270.0</i></b>	<b><u>329.0</u></b>

Table 7.4: Median Scores for Question1recode on Image of Mathematics Scales

In Table 7.4 the highest median score for each scale is highlighted in bold and underlined, while the lowest median scores are highlighted in bold italics. For all scales, students whose responses were listed as Positive Memories recorded the highest medians and this finding is consistent with previous research on past experiences of mathematics. The lowest median scores found for the scales were divided between the School and Negative Memories categories. Students in the School category were seen to have lower motivation in mathematics, less positive beliefs about mathematics and a more negative perception of mathematics as a male

domain rather than both a male and female domain. The last finding may be due in part to the slightly larger number of male students than female students in this response category. For the remaining low median scores, students with negative memories of studying mathematics were found to have lower enjoyment of mathematics, lower value of mathematics, less positive attitudes toward success in mathematics, lower self-concept of ability in mathematics, higher anxiety levels in mathematics and an overall more negative image of mathematics. Findings regarding students within the Negative Memories category are consistent with findings from previous research studies regarding past experiences and the effect of negative experiences on students' images of mathematics (see Lim, 1999; Lyons et al., 2003; Smith, 1996; Sax, 1992; Hoyles, 1982).

### **Section 7.3: Question 2**

Question 2 in the qualitative section of the questionnaire asks students *“Have your experiences of mathematics caused you to be interested/disinterested in mathematics”*. This open-ended question consists of 2 parts. Part (a) required a yes or no response from students and part (b) asked students to explain why they feel that their experiences of mathematics have caused them to be interested or disinterested in mathematics. Examining responses to this question, it appeared that some students misunderstood the initial yes or no response as ‘yes I am interested’ or ‘no I am disinterested’ and therefore in some cases students who responded ‘no’ to part (a), in fact believed that past experiences of mathematics had influenced their disinterest in mathematics. Perhaps part(a) should have been made clearer to students as *yes – interested, yes – disinterested, no – interested, no – disinterested*, and this may serve to clarify the question in any future use. As a result of this confusion, responses to part (b) were taken into account before entering the appropriate yes or no responses into SPSS for the analysis of part (a).

### Section 7.4.1: Question 2(a)

Frequency of yes and no responses to Question 2 (a) are outlined in Table 7.5. The responses rate for this question was high, with only 8 students not answering part (a).

SectionA Q2: Have your experiences of mathematics caused you to be interested/disinterested in mathematics? Yes/No					
		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	1.00 Yes	259	72.8	74.4	74.4
	2.00 No	89	25.0	25.6	100.0
	Total	348	97.8	100.0	
Missing	.00 No Answer	8	2.2		
Total		356	100.0		

**Table 7.5: Frequencies for Section A Question 2 (a)**

From Table 7.5 it can be observed that the majority of students (259 – 72.8%) responded yes to Question 2 (a), indicating that the majority of students acknowledge the influence of past experiences of mathematics on their current interest or disinterest in mathematics. A total of 89 students (25%) did not feel influenced by past experiences in their current mathematical interest or disinterest. In order to understand how these students are or are not influenced by past experiences we examine part (b) of Question 2. As this was an open-ended question there were numerous responses and therefore it was necessary to read through all students' responses and then categorise answers in order to perform some statistical analyses on SPSS.

### Section 7.3.2: Question 2(b)

Responses to Question 2 (b) were found to fall into the following 18 categories initially and are described in detail on the Appendix CD. Frequencies for the categories of responses to part (b) are displayed in Table 7.6. In this table, the

numbering 1, 10, 11,...18, 2, 3,... is formed automatically by SPSS; it is of no importance.

Section A Q2: Have your experiences of mathematics caused you to be interested/disinterested in mathematics? Please Explain					
		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	1 Disinterested - Maths Difficult	51	14.3	15.4	15.4
	10 Interested - Project Maths	2	.6	.6	16.0
	11 Disinterested - Content Not Needed	22	6.2	6.6	22.7
	12 Interested - Useful	14	3.9	4.2	26.9
	13 Depends on Topic	17	4.8	5.1	32.0
	14 Disinterested - Not Good at Maths	20	5.6	6.0	38.1
	15 Interested - Maths Easy	8	2.2	2.4	40.5
	16 Disinterested - Stressful	5	1.4	1.5	42.0
	17 Compulsory	2	.6	.6	42.6
	18 Other	38	10.7	11.5	54.1
	2 Interested - Like Maths	32	9.0	9.7	63.7
	3 Disinterested - Dislike Maths	17	4.8	5.1	68.9
	4 Disinterested - Boring	12	3.4	3.6	72.5
	5 Interested - Teacher	10	2.8	3.0	75.5
	6 Disinterested - Teacher	42	11.8	12.7	88.2
	7 Interested - Challenge	19	5.3	5.7	94.0
	8 Disinterested - Post-primary School	13	3.7	3.9	97.9
	9 Disinterested - Project Maths	7	2.0	2.1	100.0
	Total	331	93.0	100.0	
Missing	0 No Answer	25	7.0		
Total		356	100.0		

**Table 7.6: Frequencies for Section A Question 2 (b)**

The most frequently categorised response was Disinterested – Mathematics Difficult with 51 students (14.3%) becoming disinterested in mathematics as they find it too difficult. The second most common response category was Disinterested – Teacher with 42 students (11.8%) reporting a disinterest in mathematics due to negative

experiences with a teacher(s). The category Other, also contains quite a large number of students – 38 (10.7%) and this is due to the wide range of individual responses given by students. The qualitative analysis later in this chapter will however take into account the more individual responses given by students. The largest response category for interest in mathematics was Interested – Like Mathematics with 32 students (9%) stating an enjoyment of mathematics. It can be seen from the frequencies in Table 7.6 that far more students reported a disinterest in mathematics than an interest.

Question 2 (b) was correlated with the Student Profile variables – gender, co-educational status, type of post-primary school, Project Maths pilot school, Junior Certificate mathematics level, Junior Certificate mathematics grade and parent(s)’ occupation – with no significant correlations found. Part (b) was also correlated with Section A Question1recode as well as (a) of Question 2 with a small significant correlation found with Question1recode (.130,  $p < .05$ ). No statistically significant relationship was found between Question 2 (b) and the image of mathematics scales. This was also the case with Question 1 when initially categorised. Therefore the response categories for Question 2 (b) were re-coded and collapsed into broader categories as follows:

- 1) Disinterested – Subject (Dislike, Difficult, Boring, Stressful, Not Good at Maths)
- 2) Interested – Subject (Like, Challenge, Easy)
- 3) Disinterested – Content (Content Not Needed, Project Maths, Post-primary School)
- 4) Interested – Content (Useful, Project Maths)
- 5) Disinterested – Teacher
- 6) Interested – Teacher
- 7) Other (Compulsory, Depends on Topic, Others)

### **Section 7.3.3: Question 2 (b) (re-coded)**

The re-coded categories listed above, separate students' disinterest and interest with regard to: the subject of Mathematics, their feelings towards it and their mathematical self-concept; the content of the mathematics course in post-primary school; and the influence of teachers. The most frequent response category was Disinterested – Subject, accounting for 105 student responses or 29.5% of the answers. The least frequent response category was Interested – Teacher with 10 students (2.8%) attributing their interest in mathematics to a teacher or teachers. Comparing the interest and disinterest categories, 181 students (50.9%) stated a disinterest in mathematics while 93 students (26.1%) expressed an interest in mathematics. Therefore nearly twice as many students are disinterested in mathematics than are interested in mathematics. It was found that four times more students had become disinterested in mathematics as a result of experiences with teachers than had become interested (42 compared to 10). Question2brecode was next correlated with the Student Profile variables and the image of mathematics scales in order to examine any possible relationships.

The first set of variables to be examined using Pearson Correlation was the Student Profile variables. For Question2brecode, a significant correlation was found with only one of the Student Profile variables. The correlation between Question2brecode and Junior Certificate mathematics level was statistically significant at the 0.01 level (-0.14). This suggests that a weak relationship exists between students' attributions for their interest or disinterest in mathematics and students' Junior Certificate mathematics level. The relationship was examined between Question2brecode and the 8 individual 'Image of Mathematics' scales as well as the combined Image of Mathematics Scale. Table 7.7 shows the Pearson Correlation coefficients for Question2brecode and the scales.

Correlations										
		Enjoy	Value	Success	Motivation	Beliefs	Male Domain	Self Concept	Anxiety	Image of Maths
Question2brecode	Pearson Correlation	.158**	.116*	.048	.177**	.183**	.056	.103	.108*	.169**
	Sig. (2-tailed)	.003	.032	.382	.001	.001	.305	.058	.048	.003
	N	342	343	340	330	337	341	336	335	307
**. Correlation is significant at the 0.01 level (2-tailed). *. Correlation is significant at the 0.05 level (2-tailed).										

**Table 7.7: Pearson Correlation for Question2brecode with Image of Mathematics Scales**

From Table 7.7, Question2brecode correlated significantly with the Enjoyment of Mathematics Scale, Value of Mathematics Scale, Effectance Motivation in Mathematics Scale, Beliefs about Mathematics Scale, Anxiety about Mathematics Scale and the combined Image of Mathematics Scale. No statistically significant correlation was found for the Attitude toward Success in Mathematics Scale, the Mathematics as a Male Domain scale and the Mathematical Self-concept scale. It was somewhat surprising to find no significant correlation between Question2brecode and the Self-concept scale given that some students' attributions for mathematical interest or disinterest related to their self-concept of ability in mathematics. The correlation analysis supports previous research findings on the relationship between past experiences of mathematics and attitudes, beliefs, motivation and anxiety regarding mathematics (see Hoyles, 1982; Sax, 1992; Brown, 1995; Smith, 1996; Lim, 1999; Hannula, 2007, Eaton & O'Reilly, 2009). Further analyses of students' past experiences of mathematics will be discussed in the qualitative analysis section of this chapter.

### **Section 7.4: Question 3**

Question 3 in Section A poses the question to students "*Who influences you most in mathematics*". Question 3 consists of two parts: part (a) involves a tick the



box answer while part (b) asks students to explain why they are influenced by this person or group of people.

### **Section 7.4.1: Question 3 (a)**

For Question 3(a) students were given the following options to choose from as possible influences: Mathematics Teacher; Parent(s)'; Peers; Media; Other. Students were advised to choose one or a combination of the options. Each individual option was coded onto SPSS as well as all possible combination of the options. Due to the large number of response categories coded for this question, the frequency table for Question 3(a) is not shown here but can be seen in the extended version of Chapter 7 on the Appendix CD. Only one student did not respond to Question 3(a). The most frequent response chosen by students was Mathematics Teacher, with 214 students (60.1%) citing their mathematics teacher as influencing them most in mathematics. The second most frequent response was Mathematics Teacher and Parents, selected by 33 students (9.3%). The next most frequent response was for Parents and for Other, with both individual options being chosen by 24 students (6.7%). These preliminary findings are consistent with findings from the literature review (Chapter 2) where the mathematics teacher was found to be the greatest influence on images of mathematics and parents were seen to be the second largest influence. The influence of peers was also acknowledged by students in our study with 41 students (11.6%) selecting Peers as an influence, either as an individual option, or in combination with other influences. The least influential option according to students in our sample was seen to be Media as this option was only cited by 4 students as an influence, either on its own or together with other influences.

Question 3(a) was examined with regards to the Student Profile variables and a significant correlation was found for gender (0.15,  $p < .01$ ), type of post-primary school (.128,  $p < .05$ ) and Junior Certificate mathematics level (-0.14,  $p < .01$ ). The negative correlation found for mathematics level indicates a negative association between students' mathematical influences and the mathematics level studied by students, i.e. lower value categories in the mathematical influences grouping are

associated with the higher value categories in the Junior Cert mathematics level grouping and vice versa. It should be remembered that Junior Certificate mathematics level is categorised as 1=Higher level, 2=Ordinary level and 3=Foundation level. Thus it would appear that higher level students tend to have multiple influences in mathematics while ordinary level and in particular foundation level students tend to be influenced by one factor, e.g. mathematics teacher or parents. The statistically significant correlations found would suggest a weak relationship between students' mathematical influences and students' gender, type of post-primary school attended by students and the Junior Certificate mathematics level of students.

One of the chief differences that occur from the response categories to Question 3(a) when examined with regards to students' gender and Junior Cert mathematics level is regarding the influence of peers. Females were seen to acknowledge the influence of peers to a greater degree than did males and higher level mathematics students were also seen to be influenced by their peers more than ordinary level students were. The link between gender and particularly females with regards to the influence of peers was examined in the literature review Section 2.6.2 and the findings from Question 3(a) in our study support previous research findings in which females were seen to be more susceptible to the influence of peers than were males (see Simkin, 1979).

The correlation between Question 3(a) and the image of mathematics scales were also obtained using Pearson Correlation. A significant correlation was found for the Value of Mathematics Scale (0.14,  $p < .05$ ) and the Mathematics as a Male Domain scale (0.16,  $p < .01$ ). To further investigate influences on students in mathematics, we next examine responses given by students to part (b) of Question 3.

#### **Section 7.4.2: Question 3 (b)**

Question 3(b) asked students why they were influenced by the person/people chosen in part (a). As this was an open-ended question, responses were varied and had to be grouped into categories in order to perform analysis on SPSS. Responses given by students to Question 3(b) were categorized and are outlined in Table 7.8.

Section A Q3(b): Who influences you most in mathematics? Why?					
		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	1 Teacher - Only Person	103	28.9	30.4	30.4
	2 Good Teacher	44	12.4	13.0	43.4
	3 Teacher - Explains Well	27	7.6	8.0	51.3
	4 Teacher - Motivator	20	5.6	5.9	57.2
	5 Good Teacher + Help from Parents	22	6.2	6.5	63.7
	6 Help from Family	30	8.4	8.8	72.6
	7 Peers - Competition	11	3.1	3.2	75.8
	8 Bad Teacher	6	1.7	1.8	77.6
	9 Help from Peers	16	4.5	4.7	82.3
	10 No Influence	9	2.5	2.7	85.0
	11 Important Subject	20	5.6	5.9	90.9
	12 Other	31	8.7	9.1	100.0
	Total	339	95.2	100.0	
Missing	0 No Answer	17	4.8		
Total		356	100.0		

**Table 7.8: Frequencies for Section A Question 3(b)**

The most frequent response category in Question 3(b) was Teacher – Only Person meaning that 103 students (28.9%) view the mathematics teacher as their only contact with mathematics and therefore the only possible influence. The category Good Teacher was the second most common response with 44 students (12.4%) referring to their mathematics teacher as positively influencing them in mathematics. Indeed mathematics teachers were generally viewed as a positive influence rather than a negative influence with collectively, 113 students (31.8%) referring to their mathematics teacher in a positive light while only 6 students (1.7%) stated that their mathematics teacher was a negative influence. Help from Family was also a common response category (30 students, 8.4%). Similarly to previous research findings, e.g. Hanna et al. (1991) and Lim (1999), influence from parents and other family members tended to be in the form of support and encouragement, with some students turning to family members to explain any difficulties with mathematics rather than their mathematics teacher. A significant number of the responses given by students

referred to peers, either in terms of competition or comparison with other students, or receiving help and support from classmates and friends (27 students, 7.6%). The individual responses given by students to Question 3(b) will be further analysed qualitatively later in this chapter.

The 12 response categories recorded for Question 3(b) were coded onto SPSS and Pearson Correlation was performed for the Student Profile variables as well as for the image of mathematics scales. No statistically significant correlation was found between Question 3(b) and the Student Profile variables. The Pearson Correlation coefficients for Question 3(b) with the 8 scales in Section B of the questionnaire as well as the combination image of mathematics scale were found to be insignificant, indicating that no real relationship exists between students' explanations for being influenced in mathematics and students' images of mathematics. Attempts were made to re-code the categories in Question 3(b) in order to remove smaller categories (as in the case of Question1recode and Question2brecode) but even when smaller categories were grouped together, no significant correlations were found. This finding would suggest that it is the factor of influence itself (i.e. teacher, parents etc.) and not the reason for the influence which is linked to students' images of mathematics.

### **Section 7.5: Question 4**

Section A Question 4 of the questionnaire aims to discover students' causal attributions for success or failure in mathematics. Students are asked: "*Which of the following contributed most to the grade you received for mathematics in the Junior Certificate?*" with part (a) consisting of tick the box options as follows: Mathematics Ability; Effort; Luck; Level of Difficulty of Exam; Other. Students are asked to select one or a combination of the options given and in part (b) of Question 4, students are requested to explain their answer.

#### **Section 7.5.1: Question 4 (a)**

For Question 4(a), each of the options was coded onto SPSS as well as all possible combinations of the options given. The responses rate for Question 4(a) was

high with 352 students answering this item and only 4 students leaving this question unanswered. Due to the large number of combinations coded onto SPSS, as with Question 3(a), the frequency table for the response categories in Question 4(a) are not included here, but can be found in the extended version of this chapter on the Appendix CD.

The most frequent response chosen by students regarding their causal attributions for success/failure in mathematics was Effort, with 126 students (35.4%) considering the effort they made to be the main contribution to the grade they received in the Junior Certificate mathematics exam. The second most frequent response category was Mathematics Ability which was selected by 67 students (18.8%). A total of 31 students (8.7%) believed that Luck was the chief contributor to the grade they received for mathematics and 28 students (7.9%) chose Level of Difficulty of the Exam. 23 students (6.5%) did not attribute their mathematics grade for the Junior Certificate to any of the options given (Ability, Effort, Luck or Level of Difficulty) and instead chose the Other option. Many students chose Effort in combination with one or two other options: Ability and Effort – 15 students (4.2%); Effort and Luck – 13 students (3.7%); Effort and Other – 10 students (2.8%).

Question 4(a) was examined using Pearson Correlation in order to establish whether any significant relationships occurred with the Student Profile variables or the image of mathematics scales. A statistically significant correlation was found for two of the Student Profile variables – co-educational status of post-primary (-0.13,  $p < .05$ ) and Junior Certificate mathematics level (-0.19,  $p < .01$ ). In previous research studies, causal attributions for success/failure in mathematics had been linked to gender differences in mathematics. Therefore, it was surprising that no significant correlation was found between Question 4(a) and gender. Perhaps this is due to the fact that the responses in Question 4(a) make no distinction between attributions for success and attributions for failure. However, examining the percentage of males and females who selected each of the main four causal attributions we find the following:

- Mathematics Ability: Males – 24.7%, Females – 14.1%.
- Effort: Males – 29.7%, Females – 39.9%.
- Luck: Males – 9.5%, Females – 8.1%.
- Level of Difficulty of Exam: Males – 10.8%, Females – 5.6%.

Similarly to previous research findings, a greater percentage of males than females chose Mathematics Ability as having made the greatest contribution to the Junior Certificate grade received while a greater percentage of females than males selected Effort as the main contributor. A larger percentage of males than females also attributed their mathematics grade to unstable factors – Luck and Level of Difficulty of the Exam.

For the image of mathematics scales, a statistically significant relationship was found between Question 4(a) and the Enjoyment of Mathematics Scale, the correlation coefficient being -0.15 which was significant at the 0.01 level. No other significant correlations were found for the other scales. For the Enjoyment of Mathematics Scale, the highest median scores were recorded for students selecting Ability and Effort (37.0) and Mathematics Ability (35.0). The lowest median score was found for students who chose the options Luck and Level of Difficulty (19.0). The students with the highest median scores both selected Mathematics Ability as contributing to their mathematics grade for the Junior Certificate, while the majority of the students who had the lowest median scores had selected Luck as contributing to their mathematics grade. In part (b) of Question 4 we examine the explanations given by students regarding their causal attributions for success/failure in mathematics.

### **Section 7.5.2: Question 4 (b)**

Question 4(b) asked students to explain why the causal attributions selected in part (a) contributed to the grade received for mathematics in the Junior Certificate. This was an open-ended question with a variety of explanations given by students. The majority of students gave some response to this question, although 21 students gave no explanation. Answers were read thoroughly and then grouped together into

categories for coding onto SPSS. Details of the categories can be viewed on the Appendix CD. Table 7.9 outlines the frequency distributions for the response categories in Question 4(b).

Section A Q4: Which of the following contributed most to the grade you received for mathematics in the Junior Certificate? Please explain.					
		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	1 Studied/Worked Hard	107	30.1	31.9	31.9
	10 Difficult Exam	18	5.1	5.4	37.3
	11 HL to OL	17	4.8	5.1	42.4
	12 Rote Learning	18	5.1	5.4	47.8
	13 Other	28	7.9	8.4	56.1
	2 Didn't Study	26	7.3	7.8	63.9
	3 Good Teacher	12	3.4	3.6	67.5
	4 Good at Maths	26	7.3	7.8	75.2
	5 Not Good at Maths	29	8.1	8.7	83.9
	6 Tutor/Grinds	18	5.1	5.4	89.3
	7 Bad Teacher	10	2.8	3.0	92.2
	8 Luck with Exam Qs	24	6.7	7.2	99.4
	9 Studied + Good Teacher	2	.6	.6	100.0
	Total	335	94.1	100.0	
Missing	0 No Answer	21	5.9		
Total		356	100.0		

**Table 7.9: Frequencies for Section A Question 4(b)**

The most frequent response category to Question 4(b) was Studied/Worked Hard, with variations of this response given by 107 students (30.1%). The second most frequent response category was Not Good at Maths, with 29 students (8.1%) attributing their grade in mathematics to their poor mathematical ability. Good at Maths and Didn't Study were also common response categories with 26 students (7.3%) falling within each of these categories. A total of 24 students referred to their mathematics teacher as contributing to the grade they received for mathematics in the Junior Certificate (Good Teacher – 12, Bad Teacher – 10, Studied + Good Teacher –

2). Students' responses to Question 4(b) are examined in more detail in the qualitative analysis section of this chapter.

Question 4(b) was correlated with the Student Profile variables and the image of mathematics scales from Section B of the questionnaire. A statistically significant correlation was found for two of the Student Profile variables – co-educational status of post-primary school ( $-0.13, p < .05$ ) and type of post-primary school attended ( $0.15, p < .01$ ). Again no significant relationship was found between explanations of causal attributions and gender of students. Frequencies of responses to Question 4(b) were examined by gender with a table of findings displayed in the extended version of Chapter 7 on the Appendix CD. A higher percentage of females than males stated that they studied/worked hard to achieve their mathematics grade, while males were more likely than females to state that they did not study for the mathematics exam. With regards to mathematics ability, a higher percentage of males than females claimed to be good at mathematics, while a higher percentage of females than males claimed to not be good at mathematics. Males were found to refer to luck with the exam questions more than females, while a higher percentage of females believed the exam was difficult and therefore contributed to the grade they received. More females than males gave explanations regarding the transfer from higher level to ordinary level mathematics, as well as rote-learning in preparation for the mathematics exam. Therefore, although gender did not emerge as correlating significantly with students' explanations for their causal attributions of success or failure in mathematics, clearly gender differences do occur in their explanations.

Finally, when Question 4(b) was correlated with the enjoyment, value, success, motivation, beliefs, male domain, self-concept, anxiety and overall image of mathematics scales, no significant correlations were found to exist. As with the other open-ended questions previously examined (Question 1, Question 2(b) and Question 3(b)), responses to Question 4(b) were re-coded into broader categories in order to suppress the effect of smaller categories on correlations. The re-coded categories were again found to have a statistically significant relationship with students' enjoyment of mathematics.



In the analyses performed, students' causal attributions for success or failure in mathematics were found to have no real relationship with students' images of mathematics, apart from students' enjoyment of mathematics. In addition, no statistically significant relationship emerged between students' causal attributions for mathematical success or failure and students' gender. A closer examination of students' responses to Question 4, however, did reveal some gender differences, and these differences appeared to support previous research findings regarding gender differences in causal attributions for success or failure in mathematics.

### **Section 7.6: Question 5**

Question 5 is the final open-ended type question in Section A of the questionnaire survey. For this question, students were asked "*Do you use mathematics outside school and school work*". Question 5(a) requires a yes or no responses while Question 5(b) asks students who responded 'yes' to give examples of how they use mathematics, while students who responded 'no' were asked to give reasons for not using mathematics.

#### **Section 7.6.1: Question 5 (a)**

The response rate for Question 5(a) was high, with 350 students answering this item and only 6 students not giving any response. Nearly two thirds of students responded 'yes' to Question 5(a) as 232 students (65.2%) acknowledged that they use mathematics outside school and school work. However a considerable number of students – 118 (33.1%) – responded 'no', suggesting that those students are unaware of the utility of mathematics in everyday life.

Question 5(a) was correlated with the Student Profile variables and also with the image of mathematics scales, both the 8 individual scales and the combined scales. For the Student Profile variables, the only statistically significant correlation found was for gender (0.11,  $p < .05$ ). This suggests that a small relationship exists between students' understanding of the application of mathematics in the real world and students' gender. Comparing males' and females' responses to Question 5(a),

70.9% of male students responded ‘yes’ compared with 60.6% of female students. 27.2% of male students responded ‘no’ to Question 5(a) compared with 37.9% of female students, which would indicate that males are slightly more aware of the utility of mathematics outside schools than are females.

The relationship between Question 5(a) and the image of mathematics scales was examined with significant correlations found for all scales except for the Mathematics as a Male Domain scale. Pearson Correlation values are displayed in Table 7.10.

Correlations										
		Enjoy	Value	Success	Motivation	Beliefs	Male Domain	Self Concept	Anxiety	Image of Maths
SectionA Q5: Do you use mathematics outside school and school work? Yes/No	Pearson Correlation	-.365**	-.351**	-.169**	-.298**	-.207**	.038	-.283**	-.232**	-.349**
	Sig. (2-tailed)	.000	.000	.002	.000	.000	.491	.000	.000	.000
	N	338	338	335	326	334	336	331	330	304
**. Correlation is significant at the 0.01 level (2-tailed).										

**Table 7.0: Pearson Correlation for Question 5(a) with Image of Mathematics Scales**

As seen in Table 7.10, all correlations were statistically significant at the 0.01 level, apart from the Male Domain scale. Three of the correlation coefficients in Table 7.10 are above .3, indicating quite a strong relationship between students’ responses to Question 5(a) and students’ enjoyment of mathematics, students’ value of mathematics and students’ overall image of mathematics.

### **Section 7.6.2: Question 5 (b)**

For Question 5(b), students were asked to give examples for using mathematics outside school and school work or to give reasons for not using mathematics outside school and school work. Responses were grouped into categories for coding on to SPSS and are outlined in detail on the Appendix CD. The

response rate for Question 5(b) was lower than for part (a) with 33 students giving examples or reasons for the usage/non-usage of mathematics. The frequency distributions for Question 5(b) are outlined in Table 7.11.

<b>Section A Q5: Do you use mathematics outside school and school work? If so please give examples. If not, please give reasons.</b>					
		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	1 Shopping	44	12.4	13.6	13.6
	2 Money	30	8.4	9.3	22.9
	3 Sport	22	6.2	6.8	29.7
	4 Work	40	11.2	12.4	42.1
	5 Simple Maths	36	10.1	11.1	53.3
	6 Not Needed	63	17.7	19.5	72.8
	7 Dislike Maths	21	5.9	6.5	79.3
	8 Budget	13	3.7	4.0	83.3
	9 Everyday Life	14	3.9	4.3	87.6
	10 Problem-Solving	6	1.7	1.9	89.5
	11 Puzzles/Games	4	1.1	1.2	90.7
	12 Measurements	9	2.5	2.8	93.5
	13 Other	21	5.9	6.5	100.0
	Total	323	90.7	100.0	
Missing	0 No Answer	33	9.3		
Total		356	100.0		

**Table 7.11: Frequencies for Section A Question 5(b)**

The most frequent response category for Question 5(b) was Not Needed, with 63 students (17.7%) believing that they have no need for mathematics outside school and school work. The second most common response category Shopping was given by 44 students (12.4%) and the third most frequent category Work, accounted for 40 students' responses (11.2%). Students' range of responses to Question 5(b) indicates a quite high awareness of the application of mathematics to real world situations. Some of the examples were quite obvious e.g. shopping and money, while other examples given by students such as sport, farm work, problem-solving and games suggest a considerable understanding by students of the utility of mathematics in their daily lives.

From the Student Profile variables, the only significant correlation found with Question 5(b) was for Junior Certificate mathematics grade ( $-0.11$ ,  $p < .05$ ). This suggests a small but statistically significant relationship between students' responses to Question 5(b) and students' prior achievement in mathematics. Response categories were explored with respect to Junior Certificate mathematics grade (see Appendix CD for more details). Students who had higher grades in mathematics (e.g. Grade A) were found to have the highest percentage of students within the categories for Sport, Budget, Everyday Life, Puzzles/Games and Measurement, with these categories clearly indicating quite a good understanding of the application of mathematics to real world situations. Students with the lower grades in mathematics (e.g. Grade C and Other) were found to have the highest response rates in the more basic examples of Shopping and Money and also the highest percentage of responses for the categories Not Needed and Dislike Maths which were the main reasons for not using mathematics outside school and school work. Thus, the analysis of the response categories in Question 5(b) by Junior Certificate mathematics grade, indicates that students with higher achievement in mathematics have a more in-depth appreciation of how mathematics is used in daily life, while students with lower achievement in mathematics have a more basic understanding of the utility of mathematics in everyday life or are unaware of the usefulness of mathematics outside school.

Finally, Question 5(b) was correlated with the image of mathematics scales. A statistically significant correlation was found between Question 5(b) and the Beliefs about Mathematics Scale ( $0.13$ ,  $p < .05$ ) and the Mathematics as a Male Domain scale ( $0.20$ ,  $p < .01$ ). This implies a small significant relationship between students' responses regarding the utility of mathematics in their daily lives and students' beliefs about mathematics as well as students' perceptions of mathematics as a male domain. Further analysis of students' responses to Question 5 is examined in the qualitative analysis of the open-ended questions in Section A of the questionnaire. The questions in Section A of the questionnaire were also correlated with each other using Pearson Correlation. The resulting correlation matrix and findings are described in the extended version of Chapter 7 (Appendix CD).

## **Section 7.7: Qualitative Analysis**

The qualitative analysis of students' responses to the open-ended questions in Section A of the questionnaire is essential in revealing the more emotive responses given by students. The qualitative analysis highlights the importance of students' past experiences of mathematics, the factors of influence on students, students' causal attributions for success/failure in mathematics and students' awareness of the applicability of mathematics to everyday life situations. Responses on each of these issues also contribute to creating an impression of students' overall images of mathematics in terms of the five images found by Lim (1999) as discussed in Chapter 2, Section 2.14 of our literature review: Absolutist/dualistic image; Utilitarian image; Symbolic image; Problem-solving image; and Enigmatic image. In the extended version of Chapter 7 on the Appendix CD, detailed examples of students' comments can be found for each of the sub-sections in the qualitative analysis.

### **Section 7.7.1: Past Experiences of Mathematics**

Past experiences of mathematics are addressed in Question 1 (students' earliest memories) and Question 2 (students' interest/disinterest as a result of past experiences). In Section 2.6.1 of the review of the literature, a person's past experiences were seen to play a vital role in their relationship with mathematics. Past experiences of mathematics can influence attitudes, beliefs, motivation, self-concept and emotions regarding mathematics and can influence the overall image of mathematics formed. Hoyles (1982) found that 63% of students' stories on learning mathematics related to bad experiences. Similarly for our study, 53% of students referred to negative experiences of learning mathematics in Question 2(b), while only 24% of students referred to positive experiences. Students' examples of negative past experiences which led to their disinterest in mathematics tended to be more specific than students' examples of positive experiences which led to interest in mathematics. Some of the more specific negative experiences recalled by students from Question 1 and Question 2(b) are quoted here while the remainder can be seen on the Appendix CD.

- ❖ *“The teacher gave out to me and I was crying because I didn’t understand odd and even numbers”.Q1*
- ❖ *“I felt stupid not being able to do things when teachers singled me out”.Q2b*
- ❖ *“This year our school couldn’t afford a teacher for higher level maths so I’m in ordinary and I wanted to do higher”.Q2b*
- ❖ *“Had to move from higher level to ordinary level and change schools as the teacher couldn’t control the class and I couldn’t understand anything”.Q2b*
- ❖ *“Struggling and never understood it. I got upset and frustrated”.Q1*

From the examples of students’ negative experiences, it was seen that students tend to remember experiences of feeling inadequate in their mathematics ability. Not being able to concentrate in class due to a lack of control by the teacher was also a common example given by students. The school attended by students appears to play quite a significant role in students’ past experiences of mathematics which is unsurprising as the majority of students’ mathematical experiences will have taken place in a school setting. It is disconcerting however to witness the number of negative experiences caused by schools, and the resulting disinterest in mathematics this has prompted in students. For example, it is disappointing that a student who wishes to study higher level mathematics is denied the opportunity due to the school he/she attends. It is also unfortunate that students feel obliged to drop from higher level mathematics to ordinary level because of large class size or lack of discipline. There is also a sense of some students feeling neglected in favour of “brighter” students, or students who are able to learn at a faster rate. The negative experiences of mathematics cited by students often resulted in negative feelings regarding mathematics and regarding students’ mathematical ability. Students’ refer to feeling *stupid, bored, unmotivated, stressed, worried, frustrated, confused, discouraged, annoyed* and *dreading* mathematics class. These feelings expressed by students from their past experiences of mathematics, highlight their anxiety about mathematics, low self-concept, low motivation and lack of enjoyment in mathematics, reinforcing the relationship between students’ past experiences of mathematics and students’ images of mathematics.

Not all past experiences of mathematics recalled by students were negative, with many students referring to extremely positive experiences of mathematics. Some of the students' positive experiences from Question 1 and Question 2(b) are included here, while more are detailed on the Appendix CD.

- ❖ *"I like working out questions – it is fulfilling".Q2b*
- ❖ *"Interested and like maths and have an excellent teacher but have had dreadful teachers in the past (the problem with maths is the teaching)".Q2b*
- ❖ *"Maths was fun and enjoyable in primary school".Q1*

Many of the students reporting an interest in mathematics refer to mathematics as fulfilling or challenging, with students expressing an enjoyment of solving questions and feeling proud (or as one student stated *"gives you a little kick"*) when they managed to work out problems by themselves. The link between interest and achievement in mathematics also emerged from students' recollections of positive past experiences with some students stating clearly that they were interested when *"they can solve the question but hate when they don't understand"*. The higher the mathematical self-concept of students, the higher the interest in mathematics it would appear for some students. Other students claim that if they want to do well in mathematics for the Leaving Certificate, they have no choice but to be interested. Positive experiences cited by students also refer to the usefulness as mathematics, both in specific situations such as for budgeting or other school subjects, and also for everyday life in general. One student expressed a preference for group work in mathematics and using objects for bringing mathematics to life, rather than just copying mathematics from the blackboard. Some students' positive experiences of mathematics referred to having great teachers who could explain well and made mathematics fun, but in the majority of cases where students stated an interest in mathematics due to a good teacher, these students also recalled occasions when they had a bad teacher. Finally, positive feelings expressed by students in recalling positive experiences of mathematics include: *enjoy*, *motivated* and feeling *"good to accomplish it"*. The range of positive feelings expressed with regards to mathematics is considerably smaller than the range of negative feelings, mainly due to the fact that

most students recalling positive experiences described being interested in mathematics (as this was the question asked of them in Question 2 – interested or disinterested). Also, perhaps the negative experiences provoked a stronger and more emotive response in students and therefore this was expressed in the variety of emotive language used to describe their disinterest in mathematics.

For both students recalling positive and negative past experiences of mathematics, there appears to be a general consensus regarding the quality of mathematics teaching, with many students believing that sub-standard teachers and teaching practices to be one of the chief problems in mathematics education. In fact this was stated specifically by several students. It can be seen from comparison of students' positive and negative experiences of mathematics, that students are more specific in their description of negative experiences and these negative experiences are expressed in more emotive language than are positive experiences. It was observed in a study by Ruffell et al. (1998), that a specific past experience or memory of mathematics (usually a negative one) can override and dominate more general positive feelings towards mathematics. From the past experiences described by students in our study, it is easy to see how this could indeed be the case for some students.

### **Section 7.7.2: Factors of Influence**

The four main factors of influence in forming an image of mathematics as found from the literature review are teachers, parents, peers and society/media. In Question 3, Section A of the questionnaire, students are asked about their influences in mathematics. In Section 2.6.2 of this thesis, these four factors of influence are discussed. The most influential factor from the literature was seen to be mathematics teachers, followed by parents. From students' responses to Question 3(a), mathematics teachers were found to be the most influential factor for students in our study with 79.6% of students selecting their mathematics teacher(s) as influencing them in mathematics. The second most influential factor in our study was found to be students' parents as 19.4% of students acknowledged that their parents influenced



them in mathematics. Peers were the third most influential factor, with 11.6% of students feeling influenced by their peers in mathematics. Media was seen to be the least influential factor for students in our study and was chosen as a factor of influence in mathematics by only 0.8% of students.

### **Section 7.7.2.1: Mathematics Teacher**

From the previous analysis of students' past experiences of mathematics, mathematics teachers appeared more frequently in students' negative experiences of mathematics than positive experiences. From Question 3(b) however, students' descriptions regarding the influence of their mathematics teachers are mainly positive. Some of the students' descriptions regarding the influence of their mathematics teacher(s) can be found here, with more to be found on the Appendix CD.

- ❖ *“Teacher influences how interested I am and how much I learn”.*
- ❖ *“If you have a teacher that gives you confidence and makes you believe you can do it you will do better”.*
- ❖ *“The maths teacher is the only person I do maths with”.*

From the responses given by students to Question 3(b), 25.6% of students described their mathematics teacher as a positive influence with regards to mathematics while only 1.7% of students referred to mathematics teachers as a negative influence. From the descriptions given by students regarding the positive influence of mathematics teachers, it can be seen that students placed great importance on the teacher's belief in their mathematical ability. The impact of teachers' views of students' ability has been discussed in previous research, with concern regarding the possible effect on students' performance. From the sample of responses listed, it can be seen that students whose teachers encourage them and believe they can do well are more likely to try harder and want to perform better in mathematics. On the other hand, negative influence from mathematics teachers appeared to evoke a lack of motivation and feelings of anxiety in students. The majority of responses regarding the influence of mathematics teachers however, cited

mathematics teachers as being students' only association with mathematics, with the influence not being specified as positive or negative. Rather than believing that their teacher(s) have influenced their image of mathematics, it appeared that these students believed that the mathematics teacher was their only access or interaction with mathematics and the influence was in terms of learning mathematics rather than attitudes, motivation, beliefs, self-concept and emotions regarding mathematics.

### **Section 7.7.2.2: Parents**

For our study, parents were the second greatest influence on students. In addition to the influence of parents, students also referred to the influence of other family members such as siblings, grandparents, aunts, uncles and cousins. Influence from parents and family as described by students in our sample was positive and took the form of either help with understanding mathematics or support and encouragement. A number of students also stated that mathematics was an important subject to their parents. See the Appendix CD for the descriptions given by students regarding the influence of parents and family. Examples of comments relating to parental influence include:

- ❖ *“My dad is good at maths and helps me”.*
- ❖ *“They (parents) are good at maths and think I am too. They influence me to try hard and do my best because it’s a good subject to know”.*

In students' explanations regarding the influence of parents and/or family members, more students' referred to their father's influence than mother's influence. Fathers' influence was mainly in the form of help with understanding mathematics, while the influence of both parents was usually referenced when referring to encouragement and the importance of mathematics. The influence of siblings appeared to be in the form of support and encouragement, assistance with mathematics, and students' aspiring to a similarly high level of mathematical achievement. For many students citing the influence of parents or family members, mathematics was seen to be a vital subject for further education and future careers. As such, students were influenced to work hard at mathematics in an attempt to please

their parents. Many students, who were influenced by their parents in mathematics, stated that one or both parents were good at mathematics, perhaps indicating a link between parents' mathematical ability and parents' influence on students with regards to mathematics. As we have seen from our study that there is a relationship between mathematical achievement and certain aspects of students' images of mathematics, it is possible that this could also be the case for parents. Thus parents who had high achievement in mathematics may have a more positive image of mathematics and this positive image may be translated to their children by means of assistance, encouragement and the expression of mathematics as an important subject. On the other hand, parents with low achievement in mathematics may have a more negative image of mathematics. These parents may be less likely to assist their children with mathematics homework and the negative image may be transposed to their children.

### **Section 7.7.2.3: Peers**

A considerable portion (11.6%) of the sample of students in our study claimed to be influenced by their peers in mathematics. The influence of peers was mainly in the form of assistance in understanding mathematics or competition with regards to achievement in mathematics. For the most part, the influence of peers appeared to be viewed positively by students – see Appendix CD for list of statements referring to peers, including the following examples:

- ❖ *“They help you understand and motivate each other”.*
- ❖ *“You want to do as good as your friends”.*
- ❖ *“We work in groups of 4 in class and the other 3 help me and motivate me to meet their standard”.*

From students' responses, it could be seen that only two reveal the possible negative effect of peer influence, while the remainder illustrate the positive effect of peer influence in mathematics. Regarding the negative influence, comparison with peers is termed being *“judged”* by one student, who refers to mathematics as an *“elitist subject”*. For a second student, comparison with peers who are studying higher level mathematics has made him/her feel *“less able”*, clearly negatively

influencing this students' self-concept in mathematics. This finding is similar to that in Lim (1999) in which one person claimed her friends who liked and were good at mathematics made her feel inferior as she found mathematics difficult. For the other students' responses, peer influence is seen as a positive occurrence. In some cases, students clearly feel more comfortable asking for help from peers than from their teacher. It is often easier to approach a friend for help in understanding mathematics than a teacher who is a figure of authority. The support and encouragement of friends is also a positive influence on students. In particular, the reference by one student to working in groups clearly can have a positive effect on students in terms of helping each other and motivating each other. The positive effect of group work was also observed in Hill (2008). Although we have seen the negative effect of comparison with peers, this comparison or competition can also have a positive effect on students by motivating them to work harder and to *"do as good as"* classmates.

#### **Section 7.7.2.4: Media**

In our study, media was the factor with the least influence on students regarding mathematics. Comments by students on the influence of media were as follows:

- ❖ *"Video games"*.
- ❖ *"See it most of the time out and at home"*.
- ❖ *"A Beautiful Mind (film)"*.
- ❖ *"Math made out to be unbelievably important and needed for everything"*.

These four comments were the only statements made by students from our sample regarding the influence of media in mathematics. The first three responses listed by students make no real comment on how the media has influenced them personally, rather just stating a type of media or commenting on the accessibility of media. The fourth response however clearly shows that the student is sceptical about the importance of mathematics and sees the media as creating an image of mathematics which he/she does not necessarily agree with. It is clear that for the post-primary students who took part in our study, media was having little impact on their image of

mathematics, evidenced in the low number of students citing media as a factor of influence in mathematics.

The factors of influence examined in our study adhere to previous research findings for the most part. Mathematics teachers were seen to be the most influential factor, and for many students, their teacher was deemed the only possible influence to be had in mathematics. The second most influential factor found in our study was parents and family. As with findings from previous studies, parental and family influence was in the form of support and encouragement, but also as extra help or assistance in understanding mathematics school work. The influence of peers was the third most common factor and played a significant role in terms of motivating students. Help from peers and competition with peers were the main forms of influence and these had a positive effect for the most part. However, comparison with peers also clearly had a negative effect on some students in terms of their self-concept of ability in mathematics and their image of mathematics. Finally, the fourth factor of influence, media, was seen to have little or no effect on students with regards to mathematics. The factors of influence examined for students in our study undoubtedly have an effect on students' images of mathematics, particularly in terms of enjoyment of mathematics, value of mathematics, motivation in mathematics and mathematical self-concept. The influence of these factors can have a positive or negative effect on students, as witnessed from the quotes taken from students' responses.

### **Section 7.7.3: Causal Attributes for Success/Failure in Mathematics**

The causal attributions for success or failure in mathematics as used in our study are taken from Weiner (1974). His model created four categories of attribution as follows:

- **Ability** (internal and stable)
- **Effort** (internal and unstable)
- **Task Difficulty** (external and stable)

- **Luck** (external and unstable).

These four categories were then used in Section A Question 4 of the questionnaire to ask students about the grade they had received for mathematics in the Junior Certificate. Each of the four causal attributes were selected by students as reasons for succeeding in mathematics (achieving a high grade) and each of the four causal attributes were also chosen as reasons for failing in mathematics (receiving a low grade). The causal attributes are discussed separately in this section, with responses from students examined with regards to both success and failure in mathematics.

### **Section 7.7.3.1: Ability**

The first category to be examined is **ability** which is internal and stable according to Weiner (1974). Ability was selected as a factor contributing to their mathematics Junior Certificate grade by 29.2% of students. From a close inspection of students' responses to Question 4, it could be seen that while some students attributed a low grade or failure to their mathematics ability, more students attributed a high grade or success to their mathematics ability. Some of the comments made by students regarding their mathematics ability contributing to the grade they received for mathematics can be found on the Appendix CD. They include such comments as:

- ❖ *“Always had high maths ability and it is one of my favourite subjects – challenging yet logical”.*
- ❖ *“I feel confident in maths and found the exam easy”.*
- ❖ *“Could have done better if I really tried but ability also hindered me”.*
- ❖ *I failed the exam – maths not my forté”.*

The responses to Question 4(b) could be divided into three sections. The first group of responses deal with students who attribute success in mathematics to their ability. Within this group of students, responses contain positive language such as *enjoyable*, *interested* and *confident*. These would suggest that students who attribute success to their ability have a positive attitude to mathematics and a high mathematics self-concept. The second group of responses refer to students who attribute failure in

mathematics to their ability. From the comments made within this grouping, it is clear that students have a low mathematical self-concept. It would also appear that their mathematics ability is seen as something which cannot be changed or improved, as if they are inherently poor at mathematics and therefore there is no point in even trying to succeed. This belief ties in with the mathematical myth discussed in Section 2.3.3 regarding the mathematical mind, in which mathematics is seen as something which a person is naturally good or bad at. This belief suggests a low motivation in mathematics among students who attribute failure to ability. The final grouping of students' responses is that in which students refer to their ability in mathematics but in fact attribute their grade to another factor. For example, 2 respondents attribute their grade to more than just ability. The first of these blames poor teaching for having to do ordinary instead of higher level, while the second refers to the teacher's method of practising and memorising exam questions. In particular the latter response is interesting as it is clear that this student equates having memorised exam questions with having high mathematics ability. This would appear to support a rote-learning method rather than a true understanding of mathematics. A number of students who chose mathematics ability as the main causal attribute for success in mathematics in Question 4(a), went on to attribute their grade to effort and hard work. These responses indicate that for many students, mathematics ability and effort are intrinsically linked and both are necessary in order to succeed in mathematics.

### **Section 7.7.3.2: Effort**

The next causal attribute to be examined is **effort** which is internal and unstable according to Weiner (1974). Over half the sample of students in our study, 51.1% selected effort as contributing to the grade they received for mathematics in the Junior Certificate. More students attributed success in mathematics to effort than attributed failure in mathematics to effort. Examples of students' responses to Question 4(b) regarding effort are listed here with more included on the Appendix CD.

❖ *You have to put in a lot of effort to do maths”.*

- ❖ *“I worked hard to achieve my grade”.*
- ❖ *“If I put more effort in I would get a better grade”.*
- ❖ *“We had 2 teachers in 3<sup>rd</sup> year and topics were split up and difficult to learn fully so I lost interest and I didn’t study as much as I should have”.*

The responses regarding effort will be analysed separately according to effort contributing to success and effort contributing to failure. Firstly, examining students’ responses regarding effort as a causal attribute for success in mathematics, it is evident that mathematics was viewed by many of these students as a difficult subject, sometimes the most difficult subject, and as such requires a lot of study and hard work. Secondly, in cases where students described the type of effort made, repetition and rote-learning appeared to be the main methods of studying for mathematics. This finding ties in with previous research studies carried out in Ireland, e.g. Kelly & Oldham (1992), Liston & O’Donoghue (2009), Eaton & O’Reilly (2009), in which students and teachers alike had a dualistic or symbolic image of mathematics, with mathematics seen as a collection of rules and procedures to be followed. For the second group of responses regarding effort as a causal attribute for failure in mathematics, students admit to not putting in as much effort as they should but simultaneously, many students also attempt to give reasons for this lack of effort, externalising the failure (poor grade) in many cases. Examples of this ‘externalising’ of the failure include *“I didn’t get on with my maths teacher”*, *“I didn’t think I had to put in any effort when moved to ordinary level”*, and *“We had 2 teachers in 3<sup>rd</sup> year and topics were split up and difficult to learn fully”*. While some students state simply that if they had studied more they would have received a better grade for mathematics, other students clearly feel obliged to further explain their lack of mathematical success and appear reluctant to accept responsibility for failing to achieve a higher grade in mathematics for the Junior Certificate.

### **Section 7.7.3.3: Level of Difficulty**

The causal attribute of **level of difficulty** is classified as external and stable by Weiner (1974). For Question 4(a) of the questionnaire, 14.9% of students selected



level of difficulty as contributing to the grade they received for mathematics in the Junior Certificate. As with the other causal attributes, level of difficulty was cited by students as contributing to both success and failure in mathematics but in addition, the term ‘level of difficulty’ was interpreted in two ways by students. The first interpretation of level of difficulty related to mathematics level – higher, ordinary or foundation. The second interpretation referred to the exam itself, whether it was an easy or difficult exam and comparing it to exams of previous years. See Appendix CD for responses given by students to Question 4(b) relating to level of difficulty, including the following examples:

- ❖ *“Exam was o.k. and only pass (ordinary level) maths anyway”.*
- ❖ *“Wasn’t good at higher level but when I dropped to ordinary level it was easy”.*
- ❖ *“Failed exam – Higher level too much for me”.*
- ❖ *“Believe I deserved a better grade – the test was worded strangely and questions were different to previous years and confused me”.*

Level of difficulty was attributed more to failure than success in mathematics in students’ responses to Question 4(b) of the questionnaire. For students who attributed a high grade in mathematics to level of difficulty, some students referred to the difficulty of the actual exam, but most referred to the mathematics level i.e. higher/ordinary/foundation. Students’ responses regarding the level of difficulty of the actual exam, attributed their success to an easy or ‘o.k.’ exam. Students who interpreted level of difficulty as referring to mathematics level, for the most part appeared to attribute their successful grade to studying ordinary level instead of higher level. For the Junior Certificate, it appeared that these students regarded ordinary level mathematics as quite easy using phrases such as *“only pass (ordinary level) maths anyway”* and *“You don’t have to be good at maths to get an A or B in ordinary”*. While higher level is frequently referred to as difficult, these students clearly view ordinary level as easy, suggesting possibly too large a gap between ordinary and higher level mathematics, for the Junior Certificate at least. For students who attributed a lower grade in mathematics to level of difficulty, there was a fairly

even spread of responses with regards to interpretation of level of difficulty. Students, who blamed the level of difficulty of the exam itself for their poor mathematics result, described the exam as “*more difficult than usual*”, “*challenging*”, “*quite hard*” and “*worded strangely*”. These students found the exam questions difficult to understand and there was a sense of indignation and resentment that the exam was different from previous years and therefore not as they had predicted. Finally, students who attributed failure in mathematics to the mathematics level usually referred to higher level mathematics. Students’ responses referred to higher level as being difficult and that it was above their ability and they should have done ordinary level instead. Thus for the causal attribute of level of difficult, while success in mathematics was attributed to ordinary level by students, failure in mathematics was attributed to higher level mathematics.

#### **Section 7.7.3.4: Luck**

The fourth causal attribute **luck** is classified as external and unstable according to Weiner (1974). In Question 4(a), 15.6% of students chose luck as contributing to the grade they received for mathematics in the Junior Certificate. More students attributed a high grade or success in mathematics to luck than attributed a low grade or failure in mathematics to luck. Some explanations given by students in Question 4(b) regarding the causal attribute luck are included here with further examples to be found on the Appendix CD.

- ❖ “*The exam was hard so luck I got what I did*”.
- ❖ “*I’m useless at maths*”.
- ❖ “*The exam was quite easy and lucky that I looked over the right questions from the year*”.
- ❖ “*I dropped from higher level to ordinary level the day of the exam so I guessed some of the questions*”.

The responses given by students regarding luck contributing to success or failure in mathematics were varied with some referring to students’ ability, the effort made by students and the level of difficulty of the exam. Students who attributed a

high grade to luck believed that they had succeeded in spite of a low mathematical ability, little effort and a difficult exam. Phrases from the responses such as “*weakest subject*”, “*never revise*”, “*I’m useless*”, “*I didn’t bother*” suggest a low mathematical self-concept and low motivation in mathematics for some of these students. In addition, there is evidence again of rote-learning and memorising certain questions as some responses refer to the ‘right questions’ coming up on the exam. Rather than understanding the mathematics course, it is evident that some students have simply memorised formulae or particular questions that have appeared previously and their result in mathematics is down to whether the particular questions they have memorised appear. Thus their mathematics grade is indeed due to luck as well as their ability to memorise rather than their understanding of mathematics. This is also true for students who attributed failure in mathematics to luck as students refer to not having done some of the questions or only knowing a few questions and therefore they were ‘unlucky’ as they did not know the questions on the exam.

### **Section 7.7.3.5: Other**

As well as the four causal attributes already discussed, students were also offered a fifth option **other** in which they could outline other possible reasons for the grade they received for mathematics in the Junior Certificate. In part (a) of Question 4, 13.3% of students attributed their grade in mathematics to other factors. Responses from Question 4(b) regarding these other factors are outlined in detail in the extended version of Chapter 7 on the Appendix CD.

Students’ responses attributing their grade in mathematics to other factors can be grouped according to success and failure in mathematics. For students who had succeeded in mathematics, other factors contributing to their grade included mathematics teacher, grinds and family. Help from mathematics teachers was described in the form of motivation, providing mathematics notes and ensuring students were able to do previous exam questions. Students’ responses citing help from family members as contributing to their mathematics grade did not detail the type of help received but it can be assumed from the comments that it was help in

understanding and/or studying mathematics. Compared to the responses regarding other factors contributing to success in mathematics, students' responses regarding other factors contributing to failure in mathematics were more detailed and were expressed in more emotive language. Other factors contributing to a low grade in mathematics according to students' responses include mathematics teacher, time and dislike of mathematics. Descriptions referring to mathematics teachers as contributing to failure in mathematics use strong, emotive language such as *useless*, *horrible*, and *terrible*. One student referred to a bad atmosphere in mathematics class. Another student felt neglected by the teacher in favour of more able students. These descriptions of mathematics teachers contributing to a poor mathematics grade highlight a sense of resentment in students towards these teachers. In particular, one student states that his/her teacher does not even like mathematics. A basic requisite one would assume of any teacher is a liking of the subject they teach and this student clearly believed that his/her teacher disliked mathematics. It has been seen in previous research that teachers' images of mathematics are a vital factor in the process of teaching and learning (Philippou & Christou, 1998). These comments made by students in our study emphasize the impact of teachers on their students and as a result, on students' achievement in mathematics. Time was a factor mentioned by 2 students as contributing to a low grade in mathematics. For one student, not beginning the higher level part of the Junior Certificate course until half way through 3<sup>rd</sup> year left too little time to understand or complete the course thoroughly. For the second student, time was a problem during the actual exam. This student believed that feeling stressed led to *silly mistakes* and he/she ran out of time to complete the exam. Finally one student stated that they disliked mathematics and this was the reason for their poor grade in mathematics.

From Section A, Question 4 of the questionnaire, it was observed that students were more likely to attribute success in mathematics to ability and/or effort than to attribute failure in mathematics to ability or effort. Students were also more likely to attribute success in mathematics to luck than to attribute failure to luck. It was also seen that students were more likely to attribute failure in mathematics to level of

difficulty than to attribute success in mathematics to level of difficulty. Success in mathematics was more likely to be attributed to internal factors such as ability and effort, while failure in mathematics was more likely to be attributed to external factors such as level of difficulty. In addition, for some students citing effort as contributing to failure in mathematics, an attempt was made to externalise the failure by giving reasons or external factors which contributed to their lack of effort. Mathematics teachers were seen to play a role in contributing to students' success or failure in mathematics. The significance of rote-learning to students in studying for mathematics exams as well as the importance placed on exam prediction by students could be seen in the responses given to Question 4. The gap between higher and ordinary level mathematics for the Junior Certificate was also highlighted with higher level seen as too difficult but ordinary level seen as easy. The length of the higher level course also appeared to be problematic for some students in terms of content to be covered and amount of study required to succeed in higher level. Finally, students' responses regarding failure in mathematics tended to be more detailed and were expressed using more emotive language than responses regarding mathematical success.

#### **Section 7.7.4: Images of Mathematics**

In the review of the literature, Chapter 2 of this thesis, various images of mathematics were found to be held by teachers, students, mathematicians and the general public. Five categories of images of mathematics emerged from Lim (1999):

- The absolutist or dualistic image,
- The utilitarian image,
- The symbolic image,
- The problem-solving image,
- The enigmatic image.

The existence of these five images of mathematics was found not only in Lim's study, but also in other research studies as outlined in Section 2.1.4. The responses given by students in our study to the open-ended questions in Section A of the

questionnaire were analysed with respect to discovering the existence of the five images of mathematics – absolutist, utilitarian, symbolic, problem-solving and enigmatic – among the students sampled. Each of the five images was found to exist from students' comments, although some images were more widespread than others. Evidence of the five images of mathematics are discussed individually.

#### **Section 7.7.4.1: The Absolutist/Dualistic Image**

The absolutist or dualistic image of mathematics is that of a set of 'absolute truths' with only one right answer. The absolutist image of mathematics has been fostered by the style of teaching that has been experienced by many students, whereby the emphasis is placed on the product rather than the process of mathematics. On the one hand the absolutist view may result in a positive image of mathematics as there is a solution to each mathematical problem and if you find it then nobody can say you are wrong. On the other hand the absolutist view can produce a negative image of mathematics, that of a subject lacking creativity and it can be frustrating when the one true solution cannot be reached. Examples of the absolutist image of mathematics can be seen from students' responses in Section A and illustrate both positive and negative images of mathematics.

- *“Some experiences make me interested – like when you work out a new sum...on your own it gives you a little kick and makes you interested to learn”.*
- *“If I get a hard question right I feel good to accomplish it...”*
- *“I knew all the answers when I looked at the paper”.*
- *“Getting frustrated if I couldn't do it”.*
- *“...used to get very stressed”.*
- *“When I got it wrong I didn't want to do anything else”.*
- *“Stressful and frustrating”.-*

The responses listed above refer to the positive and negative effects of an absolutist image of mathematics. The importance of finding the right answer results in feelings of pleasure and achievement when the one true solution is obtained. On

the other hand, when students were unable to find the answer they felt frustrated and stressed resulting in a negative image of mathematics. One student comments that he/she did not want to continue when they were unable to find the right answer suggesting that the absolutist image of mathematics can lead to a lack of motivation in students who feel discouraged when unable to find the correct answer.

#### **Section 7.7.4.2: The Utilitarian Image**

The utilitarian image views mathematics in terms of its usage and relevance. Usually, for those who like mathematics and have a positive image, mathematics is seen as a useful tool, while for those who dislike mathematics and have a negative image, mathematics is seen as irrelevant and not to be applied to everyday life. The utilitarian image of mathematics was seen in particular from the answers given by students to Section A, Question 5 regarding the use of mathematics outside school and school work, but also appeared in the responses given to the other qualitative questions. Some examples of the utilitarian image of mathematics can be seen the following comments by students:

- *“Everyone uses mathematics in every situation if you think about it”.*
- *“The subject itself (mathematics) is a useful tool”.*
- *“You need maths for most things in life”.*
- *I am interested in the maths that would help me in the future not irrelevant maths”.*
- *“Maths is something you have to do there is no option, you will need it for the rest of your life”.*
- *“I love physics and see the usefulness of maths but think a lot of the school subject is unnecessary”.*
- *“Not everyone wants to become a scientist or engineer”.*
- *“Nothing I do that makes me use it”.*
- *“Maths from post-primary school is not needed in daily life”.*
- *“I don’t know enough to be able to successfully use it elsewhere”.*
- *“I don’t know where it can be used”.*

It can be seen from the students' responses listed, that the utilitarian image of mathematics is one which is common among the post-primary students who took part in our study. The comments made by the students referring to the utility of mathematics fall into three categories. The first set of comments are made by students who clearly have a positive image of mathematics as being useful and relevant in everyday life and necessary for the future. Mathematics is referred to as a "*useful tool*" and as seen in the analysis of Question 5 earlier in this chapter, students were aware of a variety of specific uses of mathematics in their daily lives. The second category of comments made by students regarding the utilitarian image of mathematics deals with the mathematics course they study at post-primary school. While some students state that they enjoy studying mathematics which is relevant, several students make the point that much of the mathematics they learn is unnecessary and they will not need it outside school. There appears to be a lack of awareness among these students regarding the application of school mathematics to real world situations. While the introduction of Project Maths aims to address this issue, there was no evidence of any difference between students who had studied Project Maths and students who had studied the old mathematics course with regards to the utilitarian image of mathematics. One student referring to the new Project Maths course stated that not everyone wants to become a scientist or engineer suggesting that while the importance of mathematics in these careers is highlighted to students, the value of mathematics in other areas are not commonly known to students. One student commented that "*the problem is that teachers don't explain what jobs use different topics*". There is clearly a need for a more widespread and detailed explanation to students of the relevance of mathematics in a variety of careers. The third category of students' responses in relation to the utilitarian image of mathematics highlights a complete lack of awareness regarding the utility of mathematics. Some students stated that they were unable to use mathematics as they didn't know enough to use it while others claimed that mathematics is not needed in day to day life. As found in other studies, for example Hill (2008), responses regarding the utility of mathematics in our study were varied, ranging from extremely positive to extremely negative. Some students acknowledge the usefulness of



mathematics in all aspects of life while others are completely unaware of the relevance of mathematics with one student summing up this lack of awareness stating *“nothing involves maths”*.

### **Section 7.7.4.3: The Symbolic Image**

The symbolic image of mathematics is that it is a collection of numbers and symbols, or rules and procedures to be followed and memorized. This image has similarities with the absolutist image aforementioned, with the two categories of image often going hand in hand. The symbolic image of mathematics was also a common image held by students in our study. Students’ responses relating to the symbolic image of mathematics include the following:

- *“Reciting multiples off by heart”*.
- *“Every year you begin maths it’s just a step up of the same question just with different rules”*.
- *“Teacher encourages me to learn formulas”*.
- *“Teacher made us repeat questions over and over until we knew them perfect”*.
- *“...questions were different from previous years and confused me”*.
- *“Practised exam papers again and again”*.
- *“...got by on memory”*.
- *“Learnt off all the theorems so knew one that came up”*.
- *“Studied the formulas very thoroughly”*.

There is clearly an emphasis on memorising rules and formulae in mathematics teaching in post-primary schools. This well-established ethos of teaching mathematics by focusing on learning off rules, formula and theorems has already been witnessed in previous studies such as Eaton & O’Reilly (2009) and Liston & O’Donoghue (2009). There is also a connection between this symbolic image of mathematics and exam preparation. Teachers and students alike often refer to a good exam as one in which they were able to predict the questions appearing on the exam. As such, students focus on memorising questions and rote-learning

formulae and theorems and then merely repeating these in exams. Indeed one student stated that because the exam was different from previous years he/she was confused, thus blaming an ‘unpredictable’ exam for a low mathematics grade in the Junior Certificate. Rather than memorising the mathematics rules, students need to understand what these rules mean, to understand where the formulae and theorems come from and only then will they be able to truly use the rules successfully in an exam situation.

#### **Section 7.7.4.4: The Problem-solving Image**

The problem-solving image sees mathematics as a set of problems to be solved. While this image of mathematics was not found to be as common as the previous three images of mathematics in previous research studies, the problem-solving image of mathematics was quite widespread among students in our study. Students’ responses to the qualitative questions that illustrate this problem-solving image include:

- *“Interested because I do my best to solve maths problems”.*
- *“I like problem-solving”.*
- *“It’s like figuring out puzzles”.*
- *“I like to be challenged”.*
- *“I love figuring out problems for myself”.*
- *“...encourage me to figure out things on my own”.*
- *“I was good at working things out mentally”.*
- *“Use maths to apply logic – to sort out problems”.*
- *“Sudoku and brain-training”*
- *“Puzzle-solving and order to things”.*

A considerable number of students in our sample referred to problem solving in their descriptions of mathematics. For the majority of these students, the problem-solving image of mathematics was a positive one and solving mathematical problems was an enjoyable and rewarding experience. Students referred to mathematics as a challenge and appeared to enjoy figuring out solutions to problems on their own.

Students also referred to the problem-solving image of mathematics when recalling their early memories of mathematics in the form of playing games and doing puzzles. Others mentioned problem solving when discussing the utility of mathematics, for example in Sudoku, brain-training, computer games, applying logic and creating order. Project Maths focuses on problem solving and applying mathematics to real-world problems. Therefore, it would be expected that students with a problem-solving image of mathematics would enjoy and relate more to this new mathematics course. Indeed, one student commented that *“maths is difficult but Project Maths makes it easier”*. However, the number of negative comments given by students regarding Project Maths would indicate that not all students hold a problem-solving image of mathematics and do not enjoy this approach to mathematics. Examples of students’ negative responses to Project Maths are:

- *“Project Maths hard to understand what you’re being asked”*.
- *“Disinterested – Project Maths annoying”*.
- *“Disinterested – hate Project Maths”*.
- *“Unimpressed with Project Maths”*.
- *“Disinterested because Project Maths so hard”*.
- *“Maths in school is changing which makes it annoying to learn”*.

This reaction to Project Maths may be due to the new emphasis on problem-solving or it may be a reaction to the transition from the old and familiar mathematics course to a new and unfamiliar approach. In any case, students with a problem-solving image of mathematics appear to have a higher enjoyment of mathematics and a more positive image of mathematics and for this reason alone, the introduction of the new Project Maths course with an emphasis on problem-solving could result in a more positive image of mathematics among students.

#### **Section 7.7.4.5: The Enigmatic Image**

The enigmatic image of mathematics is of something seen as mysterious but yet something to be explored and whose beauty is to be appreciated. In Lim (1999), the enigmatic image of mathematics was found to be held mainly by those who liked

mathematics and who were involved with mathematics. Mathematics was seen as something foreign and at times, incomprehensible but also elegant and something to explore. While this may be seen as a positive image of mathematics for some, for others mathematics may be seen more as a magical power, more than an ability that anyone can learn as seen in Picker & Berry (2000). This can create a negative image of mathematics as an unattainable skill, and impossible for those who do not possess a ‘natural mathematical ability’. Evidence of the enigmatic image of mathematics can be seen in the following statements made by students:

- *“It makes me think outside the box”.*
- *“I was amazed because Dad could count to 100”.*
- *“A strange interest as the years have progressed”.*
- *“It feels like you need to be excellent at it and if not there’s no place for you in the mathematics world”.*
- *“The teacher guides us through maths”.*
- *“Maths seems like an elitist subject”.*
- *“I don’t have a natural mathematical ability”.*
- *“I’m naturally good at maths”.*
- *“Naturally good at maths but you still need to study”.*
- *“I find some things easier than the other students and they come to me naturally”.*

Each of the comments made by students listed above could fit into an enigmatic image of mathematics. One student wrote that the teacher “*guides*” them through mathematics, which is similar to the metaphor of mathematics as a journey that was found by Lim (1999). There was also the impression of mathematics as being strange or making one “*think outside the box*”, which ties in with the image of mathematics as something foreign. Two of the responses given by students referred to the elitist nature of mathematics, implying that mathematics is only for the very smart and only accessible to a few with a very high mathematical ability. This is a common image of mathematics found by Ernest (1996). Finally, a number of students mentioned having a natural mathematical ability or lack thereof. The notion of the

mathematical mind or having a natural ability in mathematics is one which has been fostered by the culture of rote-learning in which the answer is most important rather than understanding the method. It has been seen from the review of the literature in Section 2.3.3 that the existence of the mathematical mind is a myth that many people believe to be a fact. As such, this has become an acceptable excuse for not doing well in mathematics. However, it has been seen from other research studies such as Butterworth (2006), that zeal and a disposition for hard work rather than innate ability are the tools for succeeding in mathematics.

### ***Section 7.8: Summary***

The qualitative analysis of Section A of the questionnaire survey highlights a number of issues regarding students' images of mathematics and learning mathematics. With regards to students' past experiences of mathematics, two main points emerged from students' responses. Firstly, many students recalling either positive or negative images of mathematics believe that sub-standard teaching to be one of the chief problems in mathematics education. Secondly, students who remembered negative experiences of mathematics were more specific in their details and used more emotive language than students who recollected positive experiences of mathematics. The next aspect examined was the factors of influence on students' images of mathematics. The most influential factor on students' images of mathematics was the mathematics teacher, followed by parents and family and then peers. Media was found to have little or no influence on students' images of mathematics. From students' responses, the factors of influence appeared to have an effect on students' enjoyment of mathematics, value of mathematics, motivation in mathematics and mathematical self-concept, and this effect may be positive or negative. Next, the causal attributes for students' success or failure in mathematics were explored. Students were seen to be more likely to attribute success rather than failure in mathematics to ability, effort and luck, while failure was more likely to be attributed to level of difficulty. Furthermore, success was more likely to be accredited to internal factors, while failure tended to be blamed on external issues. In addition, students also believed that the mathematics teacher plays a role in students' success

and failure in mathematics. Finally, students' responses from Section A were assessed in relation to the five images of mathematics – absolutist, utilitarian, symbolic, problem-solving and enigmatic. Each of the five images was found to be present among the students sampled. The absolutist, symbolic and enigmatic images were found to exist, often as a result of the culture of rote-learning which has been commonplace in post-primary schools in Ireland. The utilitarian and problem-solving images were the most common images of mathematics from the comments made by students in our study. The qualitative analysis highlighted the need for more detailed and widespread explanation regarding the relevance of mathematics in daily life and in a variety of future careers. It is also necessary to emphasise understanding the mathematical process rather than memorising rules. Finally, the problem-solving image appeared to have a positive effect on students' enjoyment of mathematics and this may have implications for the Project Maths course, which focuses on solving problems from real world situations.

## **Chapter Eight**

**What is the Image of Mathematics held by Post-primary Students in Ireland? A discussion on findings from the quantitative and qualitative data analysis**

## **Chapter Eight: What is the Image of Mathematics held by Post-primary Students in Ireland? A discussion on findings from the quantitative and qualitative data analysis**

In this chapter I discuss the findings from the analyses conducted on both quantitative and qualitative data. The research questions that were outlined in Section 3.6 of Chapter 3 are addressed. Students' attitudes, beliefs, motivation, self-concept and emotions regarding mathematics are explored, as is the overall image of mathematics held by students. Differences are also discussed in terms of gender and prior achievement. Students' past experiences of mathematics, causal attributions for success/failure in mathematics and the factors influencing students' images of mathematics are discussed. Our findings are discussed in relation to the research studies that were considered in Chapter 2. Findings from the analysis are also considered with regards to two issues that are of current national interest – Project Maths and the low number of students taking higher level mathematics for the Leaving Certificate.

### ***Section 8.1: Addressing the Research Questions (part a)***

In this section and the following section I look back at the research questions that guided the research study and attempt to answer these questions from our findings. The main research question “*What is the image of mathematics held by 5<sup>th</sup>-year post-primary students in Ireland?*” will be the final question to be examined, as it is the ultimate concern of our study and all other research questions will provide some information in addressing this fundamental question.

In this section I examine the research questions dealing with the elements incorporated in our definition of image of mathematics, namely; attitudes, emotions, beliefs, self-concept and motivation regarding mathematics.



### **Section 8.1.1: Do 5<sup>th</sup>-year post-primary students in Ireland have a positive or negative attitude toward mathematics?**

The first research topic to be discussed is the attitudes of students to mathematics. In Sections 6.2.1 and 6.2.2, students' attitudes were examined in terms of their enjoyment of mathematics (Aiken, 1974), value of mathematics (Aiken, 1974), and attitude toward success in mathematics (Fennema & Sherman, 1976). Findings indicated that students have a low enjoyment of mathematics but assigned a high value to mathematics and have a positive attitude to mathematical success. The three measures of attitude were also found to have significant, positive correlations with each other, the strongest correlation being between the enjoyment and Value scales, and the weakest correlation being between the enjoyment and attitude to Success scales (see Section 6.5.1). Partial correlation, Principal Components Factor Analysis and Multiple Regression analysis highlighted a strong relationship between students' enjoyment of mathematics and value of mathematics, but students' attitude toward success in mathematics was consistently seen to be separate from these attitude measures. Thus in addressing the research question *“Do 5<sup>th</sup>-year post-primary students in Ireland have a positive or negative attitude toward mathematics?”* I separate the measures of attitude into:

- Attitude toward Mathematics – Enjoyment of Mathematics and Value of Mathematics (Scales by Aiken, 1974).
- Attitude toward Mathematical Success – Attitude toward Success in Mathematics (Scale by Fennema & Sherman, 1976).

With regards to students' attitudes toward mathematics, in general students were seen to have a negative attitude to mathematics in terms of enjoyment but a positive attitude to mathematics in terms of value. Students in general had a positive attitude toward mathematical success. But which aspect of attitude is the most important and has the greatest impact on students' images of mathematics?

From the analysis of the quantitative data it could be argued that students' enjoyment of mathematics plays the most significant role in shaping students'

attitudes and in contributing to the image of mathematics held by students. The Enjoyment of Mathematics Scale had a higher Cronbach alpha value than the Value of Mathematics Scale and the Attitude toward Success in Mathematics Scale indicating that the Enjoyment scale was more reliable for our sample of students. In our study, the Enjoyment of Mathematics Scale was frequently seen to have a stronger relationship with the other elements of the image of mathematics, namely students' motivation, beliefs, self-concept and anxiety. The Enjoyment scale also was found to have a higher correlation value with the combined Image of Maths scale than did the value or attitude to Success scales. Findings from the qualitative data also support the importance of students' enjoyment of mathematics. In Section 7.3.3 students' explanations for interest or disinterest in mathematics were found to have a stronger correlation with the Enjoyment scale than with the Value of scale or Success scale. Students' interest or lack of interest in mathematics may play a role in students' achievement in mathematics (a significant correlation was found with prior achievement in mathematics) and their decision to continue to study mathematics after post-primary school. As such, students' enjoyment of mathematics could be seen as the most vital aspect of attitudes to mathematics. In a study by Mettas et al. (2006), students who tended to have the highest achievement scores for science showed the highest enjoyment of learning science. Liston (2009) found that students' enjoyment of mathematics had an influence on their performance in mathematics. The ERSI (NCCA, 2007) study on students in 3<sup>rd</sup>-year post-primary school found that while fewer than half of the students sampled found mathematics interesting, nearly 90% of students viewed the subject as useful. The ESRI group suggests a contradiction between what students perceive as being important and their response to the actual experience. This contradiction between enjoyment and value of mathematics was also found by Sturman et al. (2008) in their analysis of TIMSS 2007. They observed that high performance but low enjoyment of mathematics was common in high scoring countries, and they noted that *"pupils generally valued their learning in mathematics, despite their relative lack of enjoyment of it; they clearly recognise that it can be useful to them"*. Wilson (2011) adds that the findings by Sturman et al. (2008) suggest that students may be disposed to engage in

mathematics, despite attitudes or affective responses that would appear to repel this engagement. Thus, it can be argued that – more than enjoyment – students’ value of mathematics is the vital component that motivates their mathematical engagement and performance.

Students’ enjoyment and value of mathematics were also seen in our study to be related to their prior achievement in mathematics. For the Enjoyment and Value scales, a positive and significant correlation was found with Higher Level Grade A while a negative, significant correlation was found for the Enjoyment scale with Ordinary Level Other and for the Value scale with Ordinary Level Grade C. Thus students with the highest prior achievement tend to have a higher enjoyment and valuation of mathematics while students with lower prior achievement tend to have lower enjoyment and valuation of mathematics. This is consistent with the findings of Mettas et al. (2006) and Aiken (1970). Ma & Kishor (1997) found no significant relationship between prior achievement and attitudes to mathematics but Brassell et al. (1980) found that the lower-end pupils in a medium-level ability mathematics class had the lowest scores for enjoyment of mathematics, suggesting that lower achievement in mathematics can negatively influence students’ attitudes to mathematics, which is similar to our own findings. Evidence of the relationship between prior achievement and attitudes to mathematics can also be seen in Stevenson & Newman (1986).

As a strong relationship has been found to exist between enjoyment and value of mathematics in our study, perhaps both are vital elements in shaping students’ attitudes toward mathematics. On the other hand, students’ attitudes to mathematical success do not appear to play such a significant role. With students in our study seen to have generally positive attitudes to mathematics in terms of value, I would suggest that there is clearly a need to nurture students’ enjoyment of mathematics, and this nurturing would lie in the realm of mathematics teaching and learning.

### **Section 8.1.2: What feelings/emotions do 5th-year students in Irish post-primary schools associate with mathematics?**

The second research question I look at relates to students' emotions or feelings regarding mathematics, and this is examined in our study by the Anxiety about Mathematics Scale (Fennema & Sherman, 1976). A high variance of scores was found for the Anxiety scale with some students found to have high anxiety about mathematics while other students had low anxiety. It should also be noted that gender differences were seen to play a considerable role with regards to the Anxiety scale. Gender was found to have a moderate effect on students' anxiety about mathematics; explaining 9% of the variance (see Section 6.5.6.1). There was a statistically significant difference found between the anxiety scores for males and females with females found to have higher anxiety levels than males. Apart from the Male Domain scale, gender had the strongest impact on students' anxiety about mathematics and this link between anxiety and gender is consistent with previous research findings – see Pedro et al. (1981), Hembree (1990), Perkins et al. (2007).

Students' anxiety about mathematics was found to be strongly related to their enjoyment of mathematics, motivation in mathematics and self-concept in mathematics, particularly the last factor – see Section 6.5.2. The strong relationship between students' anxiety about mathematics and their mathematical self-concept is consistent with previous research findings such as Fennema & Sherman (1976) and Hoyles (1982). However the most revealing information regarding students' feelings and anxiety levels in mathematics can be found in the analysis of the qualitative data.

In Section 7.2.2, students' past experiences of mathematics were examined in relation to the image of mathematics scales. Comparing the median scores for the past experience categories, students with negative memories of mathematics were found to have the lowest median score (28.0) on the Anxiety scale and therefore the highest anxiety levels, while students with positive memories of mathematics were found to have the highest median score (42.5) and therefore had the lowest anxiety levels regarding mathematics. This finding relates to Hoyles (1982) who states that past experiences of mathematics influence students' current mathematics anxiety. The

Anxiety about Mathematics Scale also had a significant correlation ( $p < .05$ ) with students' reasons for being interested or disinterested in mathematics. Hoyles (1982) suggested that one of the explanations for mathematics anxiety relates to mathematics teaching and learning, and Fennema & Sherman (1976) stated that anxiety about mathematics can hinder learning in mathematics.

Examining the language used by students' in their responses to the open-ended questions, students with negative experiences of mathematics and learning mathematics were seen to feel 'stupid', 'stressed', 'worried', 'frustrated' 'confused', 'discouraged' and 'dreading' mathematics class – see Section 7.7.1. Students used emotive language to express feelings of inadequacy and anxiety relating to mathematics and there was far more evidence of negative emotions relating to mathematics than positive emotions. Positive emotions relating to mathematics tended to be more sedately expressed with students stating that they felt 'motivated', 'enjoyed' maths and felt 'good to accomplish it' – see Section 7.7.1 also.

Overall, from both the quantitative and qualitative findings, it would appear the students in our study had both positive and negative emotions regarding mathematics, but students with negative emotions were seen to be more widespread and more vocal in expressing these emotions. Feelings of inadequacy, anxiety and frustration were common among students, particularly in relation to negative experiences of mathematics learning. Females were seen to have higher anxiety regarding mathematics than males with gender differences seen to explain a significant portion of the variance in students' anxiety levels.

### **Section 8.1.3: Do 5th-year post-primary students in Ireland have confidence in their mathematical ability?**

The third research question to be discussed is in relation to students' self-concept of ability in mathematics and is examined in our study by the Mathematical Self-concept scale (Gourgey, 1982). Similarly to the Anxiety scale, students were seen to have a wide range of scores on the Self-concept scale, with some students displaying high confidence in their mathematical ability and others having low

confidence in their ability. The Mathematical Self-concept scale was highly correlated with the Anxiety about Mathematics Scale in our study, as previously mentioned, with high self-concept associated with low anxiety and low self-concept associated with high anxiety. This was also found to be the case in the original analysis of the Mathematical Self-concept scale by Gourgey (1982), although a different scale (MARS) was used to measure anxiety in her original analysis. There was also a strong relationship found between students' self-concept in mathematics and their enjoyment, motivation and beliefs regarding mathematics as seen from the Multiple Regression analysis performed in Section 6.5.4.7.

From the analysis of the qualitative data, students' mathematical self-concept was seen to be related to past experiences of mathematics. Students with negative memories of mathematics had the lowest self-concept and students with positive memories of mathematics had the highest self-concept. As already mentioned in the previous section, negative experiences of learning mathematics were seen to be associated with feelings of inadequacy for some students, further indicating a link between students' past experiences of learning mathematics and their mathematical self-concept. There was evidence of students' self-concept of ability regarding mathematics in their responses to the open-ended question on their causal attributions for success/failure in mathematics. A number of students who attributed success in mathematics to their mathematics ability stated a confidence in their ability, while students who attributed their failure in mathematics to their ability clearly showed a low mathematical self-concept. For some students attributing failure in mathematics to the level of difficulty, higher level mathematics was seen as too difficult for their ability, suggesting students have a low self-concept in relation to their ability to study higher level mathematics specifically. Of the students who attributed their success in mathematics to luck, some of the responses clearly highlighted low mathematical self-concept among students. One student claimed 'I'm useless', a patent expression of low self-confidence in mathematics.

Finally, students' mathematical self-concept was found to be significantly correlated with their prior achievement in mathematics, particularly at the extremes,

i.e. for students with the highest levels of achievement (Higher Level Grade A, Ordinary Level Grade A and Ordinary Level Grade B) and for students with the lowest levels of achievement (Ordinary Level Grade C and Other). This connection found between students' prior achievement and their mathematical self-confidence is consistent with previous research findings. Fennema & Sherman (1976) found that self-confidence in mathematical ability was highly correlated with achievement in mathematics, more so than any other affective variable. In Liston (2009) self-concept was seen to influence performance in mathematics, with similar findings in Brassell et al. (1980) and Cheung (1988).

Thus, in response to the research question as to whether students have confidence in their mathematical ability, it is evident that while some students have high confidence in their ability, other students have a very low self-confidence in mathematics. This confidence is related to students' past experiences of mathematics, and is also influenced by students' prior achievement in mathematics. The findings also indicate that some students have low self-confidence in their ability to learn higher level mathematics, but are confident in their ability to learn ordinary level mathematics.

#### **Section 8.1.4: What beliefs do Irish post-primary 5<sup>th</sup>-year students hold about mathematics?**

The next research question refers to students' beliefs about mathematics. Students' beliefs are examined in the Beliefs about Mathematics Scale (Schoenfeld, 1989) and the Mathematics as a Male Domain scale (Fennema & Sherman, 1976). The latter scale examines students' beliefs regarding gender and mathematics. For our study, the Beliefs about Mathematics Scale was found to have a very low reliability, with a Cronbach alpha value of only .21. Therefore, findings from this scale should be interpreted cautiously. From the preliminary analysis of the scales (Section 6.2.2), the mean score for the Beliefs scale was found to be similar to the "unsure" score (19.25) with a low variance (11.43). It would seem that students were uncertain about the items contained in the Beliefs scale. For the Mathematics as a Male Domain scale, a high reliability was found (.86), The Male Domain scale also had the highest mean

score of all the 8 scales used in our study (48.62) but it also had quite a large variance (73.10) and gender differences account for a considerable portion of this variance – 14%, as found by the independent samples t-test (Section 6.5.6.1). Indeed, gender differences were found to have a larger effect on the Male Domain scale compared to the other 7 scales used, with females seen to have more positive beliefs about mathematics as a domain for both males and females while males were seen to have more negative beliefs about mathematics as a domain for males rather than females. This finding relates to the study by Kaiser-Messmer (1993) who found that while girls' views of gender roles have altered significantly in recent decades, boys tended to adhere more to gender-typical roles.

While the findings from the analysis of the quantitative data were not very informative regarding the beliefs about mathematics held by students, the qualitative data gives us some insight into students' beliefs. A significant correlation was found between students' memories of mathematics and the Beliefs about Mathematics Scale and the Mathematics as a Male Domain scale. Students' reasons for being interested or disinterested in mathematics correlated significantly with the Beliefs scale while students' influences in mathematics correlated significantly with the Male Domain scale. A significant correlation was also found for students' awareness of the utility of mathematics with both the Beliefs scale and Male Domain scale. From the review of research studies on beliefs about mathematics (see Section 2.3), a number of stereotypical beliefs were found to exist. In particular, the belief that some people have a mathematical mind or a natural ability for mathematics was seen to be widespread, as was the belief that mathematics involves memorizing rules. In students' responses to the open-ended questions, both of these mathematical myths were found to exist among students in our sample. In Section 7.7.3.1 it was observed that students' viewed their mathematics ability as something which could not be changed or improved, with mathematics seen as something they were either naturally good or bad at. The belief that mathematics requires a natural ability appeared to be more common among students who had a lower prior achievement in mathematics as many of these students had cited their mathematics ability as contributing to a poor



grade in mathematics. Students who cited mathematics ability as the reason for their success in mathematics often included hard work and effort in their explanation for mathematical success. This suggests a belief that ability and effort are both required to succeed in mathematics which ties in with the findings of Breen et al. (2007) who found that 58% of students believed that ability in mathematics could be aided and improved by hard work. In Section 7.7.3.2 and Section 7.7.3.4, there is evidence of the belief among students that mathematics requires memorizing rules, formulae and exam questions. Rote-learning was seen to be commonplace for students in our study as was the case in other studies carried out in Ireland such as Kelly & Oldham (1992), Liston & O'Donoghue (2009) and Eaton & O'Reilly (2009). Evidence of the symbolic image of mathematics – see Section 7.7.4.3 – was found in our study, with an emphasis placed on memorisation and exam prediction.

Thus, to answer the question as to what beliefs are held by 5<sup>th</sup>-year post-primary students regarding mathematics, it can be seen that many students believe that mathematics requires memorizing rules and formulae. Some students believe that mathematics requires a natural ability and students with lower achievement in mathematics tend to believe they do not possess this natural ability. On the other hand, students who have a higher achievement in mathematics tend to attribute their success to hard work and effort as well as their ability. Male students tended to have more negative beliefs regarding women and mathematics while females held the more positive beliefs about mathematics as a domain for both males and females.

#### **Section 8.1.5: Are 5<sup>th</sup>-year post-primary students in Ireland motivated regarding mathematics?**

The final research question in this section relating to the elements included in our understanding of image of mathematics refers to students' motivation, which is examined by the Effectance Motivation in Mathematics Scale (Fennema & Sherman, 1976). In the preliminary analysis of the Motivation scale, 8 of the 12 items in the scale had a low mean score indicating a general low motivation in mathematics. The Effectance Motivation in Mathematics Scale had a high reliability with a Cronbach alpha value of .84. A strong relationship was found in the analysis of the quantitative

data between students' motivation in mathematics and their enjoyment, value, self-concept and anxiety regarding mathematics and to a lesser extent, between students' motivation and beliefs. There also appeared to be a relationship between prior achievement and students' motivation, in particular for students who had studied higher level mathematics for the Junior Certificate – see Section 6.5.6.2. Students who received a higher level Grade A in mathematics for the Junior Cert (the highest level of achievement) were found to have the highest motivation in mathematics for our study. This is consistent with findings by Reynolds & Walberg (1992) who found that motivation influences and is influenced by achievement in mathematics.

In the analysis of the qualitative data, students' motivation in mathematics was found to have a significant correlation with students' earliest memories of mathematics. Students with positive memories of mathematics had the highest median score for motivation in mathematics. A significant correlation was also found between the Motivation scale and students' reasons for mathematical interest or disinterest. Students' mathematics teachers also appear to have an influence on students' motivation. From students' descriptions of mathematics teachers as a positive influence (see Section 7.7.2.1), it can be seen that teacher encouragement led students to try harder and to become more motivated to succeed in mathematics. On the other hand, students recalling the negative influence of mathematics teachers indicated a lack of motivation. Parents were also seen to have an influence on students in terms of motivation, particularly when parents were known to view mathematics as a vital subject for further education and future careers (Section 7.7.2.2). There was also a positive influence from peers in terms of motivation for some students, with competition with peers and encouragement from friends prompting students to work harder at mathematics, particularly when working in groups (see Section 7.7.2.3)

Overall, students tended to have a low motivation in mathematics, with students' motivation related to their past experiences, their interest/disinterest in studying mathematics and prior achievement. Students with the highest level of prior achievement had the highest levels of motivation in mathematics. The factors

influencing students' images of mathematics, specifically teachers, parents and peers, were seen to have an influence on students' motivation in mathematics in particular.

So far, the research questions discussed have related to elements of students' images of mathematics; attitudes, beliefs, self-concept, emotions and motivation. The next set of research questions that I examine relate to the various factors that may influence students' images of mathematics and give us a more in-depth insight into students' images of mathematics.

## ***Section 8.2: Addressing the Research Questions (part b)***

In this section, I look at the research questions relating to students' past experiences of mathematics, their causal attributions for success and failure in mathematics, the factors influencing students in forming an image of mathematics and the relationship between prior achievement in mathematics and students' images of mathematics. These research questions are mainly answered by the findings from the qualitative data analysis, except the question regarding prior achievement which is investigated in the study by analysing students' Junior Certificate mathematics level and grade in relation to their images of mathematics.

### **Section 8.2.1: Do their past experiences of mathematics impact on 5<sup>th</sup>-year post-primary students' current images of mathematics?**

Students' past experiences of mathematics are examined in Section A of the questionnaire, Questions 1 and 2. Students were asked about their earliest memories of mathematics and about their experiences of mathematics influencing their current interest or disinterest in mathematics. Similarly to the findings of Hoyles (1982), the majority of students' recollections of learning mathematics related to negative experiences – 53%, compared with 24% relating to positive experiences. The majority of students – 72.8% - agreed that their past experiences of mathematics had caused them to be either interested or disinterested in mathematics. Nearly twice as many students were found to be disinterested in mathematics than were interested, 181 (50.9%) compared to 93 (26.1%). Therefore it follows that students' experiences of learning mathematics were more likely to lead to a disinterest in mathematics than

to fuel an interest in mathematics. Reasons for this disinterest in mathematics indicated a low enjoyment of mathematics, a low value of the mathematics taught in post-primary school, negative beliefs about mathematics, high anxiety (in cases where mathematics was found to be stressful), a low mathematical self-concept and low motivation (subject difficult or boring) among students. Overall it is clear that students who are disinterested in mathematics as a result of their experiences of learning mathematics have a generally negative image of mathematics and learning mathematics. On the other hand, for students who stated an interest in mathematics, reasons for this interest indicated a high enjoyment of mathematics, a positive value of mathematics, a high mathematical self-concept (for students who find mathematics easy) and a high motivation in mathematics. Overall, students who are interested in mathematics tend to have a more positive image of mathematics, particularly in terms of attitudes, self-concept and motivation.

Further evidence of the impact of students' past experiences of mathematics on their current images of mathematics can be found in the significant correlations found between students' earliest memories of mathematics and the image of maths scales, and between students' interest/disinterest in mathematics and the image of maths scales. In Section 7.3.3, students' explanations for mathematical interest or disinterest were found to have a significant correlation with the Enjoyment, Value, Motivation, Beliefs, and Anxiety scales as well as with the combined image of mathematics scale. Although the correlation values were low, there still exists a weak but significant relationship between students' experiences of mathematics leading to interest or disinterest and students' current images of mathematics. The relationship between experiences of learning mathematics and images of mathematics was found to exist in Lim (1999) and Eaton & O'Reilly (2009) and is also supported by Brown (1995).

In addition, from Section 7.2.2, students with positive memories of mathematics had the highest median scores for each of the image of mathematics scales. Conversely, students with negative memories of mathematics were found to have the lowest median scores for 5 of the 8 image of maths scales. These students

had the lowest enjoyment levels, the lowest value, a more negative attitude to success, lower self-concept and higher anxiety levels in relation to mathematics and overall, students with negative memories of mathematics had the most negative image of mathematics. This finding is a clear indication that past experiences of mathematics have an impact on students' current images of mathematics and therefore answers our research question.

### **Section 8.2.2: Who Influences Irish 5<sup>th</sup>-year post-primary students most in terms of mathematics and the formation of their image of mathematics?**

Findings from the analysis of the qualitative data on the factors influencing students in mathematics were consistent with previous research findings by Lim (1999) in the UK. In our study, the greatest influence on students in mathematics was found to be mathematics teachers, followed by parents and then peers. Media was found to have no real influence on students as this option was chosen by only 4 of the 356 students who took part in our study. A total of 214 students (60.1%) cited their mathematics teacher as being the greatest influence on them regarding mathematics and 103 of these students (28.9% of the sample) believed that their mathematics teacher was the only possible influence in mathematics as he/she is the person teaching students mathematics. A weak but statistically significant relationship was found between students' influences in mathematics and students' gender, the type of post-primary school attended by students and the Junior Certificate mathematics level of students. One of the most noticeable differences between genders regarding mathematical influences was in relation to the influence of peers. Females acknowledged the influence of peers to a greater degree than males and this may relate to a study by Simkin (1979) who found that females value peer-popularity more than males. Although there is no indication of the valuation of popularity in our study, there is an indication that females are more likely to be influenced by their peers than males are, at least in relation to mathematics. Students who had studied higher level mathematics for the Junior Certificate were also more likely to acknowledge influence from peers than were students who had studied ordinary level. Students' influences in mathematics were also found to be significantly correlated

with their value of mathematics and their perception of mathematics as a male domain, the latter perhaps not surprising given the aforementioned relationship with gender.

Influence from mathematics teachers was mainly found to be positive with 25.6% of students referring to their teacher as a positive influence while only 1.7% cited their mathematics teacher as a negative influence. From students' responses, it is clear that students placed great importance on the teacher's belief in the mathematical ability of the students. Dweck (1986) and Lyons et al. (2003) have expressed concern that teachers' views of students' ability can affect students' performance and from our study, this may indeed be the case as one student stated: *"If you have a teacher that gives you confidence and makes you believe you can do it you will do better"*. Although most students who cited their mathematics teacher as influencing them in mathematics referred mainly to learning mathematics, there is an implicit effect to be seen from the influence of teachers on students' images of mathematics, particularly in relation to motivation, self-concept and enjoyment of mathematics. The influence of teachers could also be found from the qualitative data analysis as a small number of students cited their mathematics teacher as influencing the grade they received for mathematics in the Junior Certificate. The comments made by students on this regard, particularly the negative descriptions of teachers contributing to a poor mathematics grade, emphasize the impact of mathematics teachers on their students and as a result, on students' achievements.

For our study, the second greatest influence on students in mathematics was parents or other family members. Influence from parents and family was entirely positive and was in the form of either help in understanding mathematics, or encouragement and support. Parental support was also found to be a major influence on students by Lim (1999) and Hanna et al. (1991). Similarly to Lim (1999) and Fennema & Sherman (1976), the influence of fathers was more frequent than the influence of mothers. Fathers were most commonly seen to assist students in understanding mathematics while both parents were seen to be a source of encouragement. For many students who stated that they were influenced by their

parents or family, mathematics was seen as a vital subject for further education and future careers suggesting a link between the influence of parents and students' valuation of mathematics.

Peers were considered as an influence in mathematics by 11.6% of students in our study. For the most part, influence from peers was viewed as positive, with some students feeling more comfortable asking for help from their peers than from a teacher. Support and encouragement from peers was also evident from student responses, and group work was also seen as a beneficial influence in mathematics. The positive effect of group work was also noted in Hill (2008). Competition with peers was also found to be an influence on students in our study, as students strive to do as well as their classmates and compete for higher grades in mathematics. This competitiveness can be seen to influence students in terms of motivation. Regarding the negative influence of peers, comparison with peers made one student feel 'judged' while another student clearly had a low mathematical self-concept due to the fact that she was studying ordinary level mathematics while her friends were studying higher level. This is similar to Lim's (1999) study in which one person stated that her friends who were good at mathematics made her feel inferior as she found mathematics difficult.

Overall, the findings show that mathematics teachers, parents and peers all influence students in mathematics and this influence can be seen to have an impact on students' images of mathematics, especially in terms of students' enjoyment of mathematics, value of mathematics, motivation in mathematics and mathematical self-concept.

### **Section 8.2.3: What are the causal attributions of Irish post-primary students in 5<sup>th</sup> year for success and/or failure in mathematics and do gender differences occur?**

Findings from our study relating to the causal attributions for success/failure in mathematics were examined in relation to students' grades for Junior Certificate Mathematics. Each of the causal attributes from Weiner (1974) was found to apply to

students in our study; ability, effort, level of difficulty and luck. The most frequent causal attribute selected by students in our study was effort, chosen by 126 students (35.4%) as the main factor contributing to their Junior Cert mathematics grade. This finding is similar to Tait-McCutcheon (2008) who found that the majority of students attributed success in mathematics to controllable factors such as hard work. Ability was the second most frequent choice – 67 students (18.8%), followed by luck – 31 students (8.7%) and level of difficulty – 28 students (7.9%). While students' causal attributions for success/ failure were found to be significantly correlated with the co-educational status of schools attended by students and with the Junior Certificate mathematics level of students, no significant correlation emerged for gender. This was surprising given that Fennema (1977) and Pedro et al (1981) had found that gender played a significant role in the causal attributions for success or failure in mathematics. Therefore, I examined the causal attributes in further detail by looking at the percentage of males and females who chose ability, effort, level of difficulty and luck. This revealed that a greater percentage of males than females selected mathematics ability as contributing to their grade while a greater percentage of females than males chose effort as contributing to their grade. This finding is consistent with the findings of Fennema and Pedro et al. Furthermore, a higher percentage of females than males stated that they worked hard to achieve their grade while a higher percentage of males than females stated that they did not study for the mathematics exam and therefore received a poor grade. A higher percentage of males claimed to have a good mathematics ability while a higher percentage of females claimed to have a low mathematics ability.

In relation to students' images of mathematics, the only significant correlation was found between students' causal attributions for success/failure in mathematics and their enjoyment of mathematics. Students who attributed their mathematics grade to high mathematics ability had the highest enjoyment levels of mathematics while students who attributed their mathematics grade to luck had the lowest levels of enjoyment. From the examination of students' responses however, it was clear that students' causal attributes for success/failure had a relationship with their images of



mathematics. For students who attributed success in mathematics to ability, responses indicated a positive attitude toward mathematics, particularly in terms of enjoyment, and a high mathematical self-concept. Students who attributed failure in mathematics to their ability indicated a low mathematical self-concept from their responses. There was also evidence of low levels of motivation among these students as many believed that their poor mathematics ability could not be changed or improved and therefore there was no point in trying to succeed. Effort was mainly cited by students as contributing to mathematical success. But for the students who attributed a poor grade in mathematics to a lack of effort, this would signify low motivation in mathematics. With regards to the level of difficulty of the exam, the most noticeable point to emerge from students' responses relates to the differences between higher level and ordinary level mathematics. As previously mentioned in Section 8.1.3, students could be seen to have a low mathematical self-concept regarding higher level mathematics but generally a higher mathematical self-concept for ordinary level mathematics. Success was mainly attributed to ordinary level, while higher level was blamed for failure by several students. Finally, for students who attributed their grade in mathematics to luck, there was an indication of low mathematical self-concept and low motivation from their responses.

Apart from Weiner's (1974) causal attributions, a small number of students referred to other factors as contributing to the grade they received for mathematics in the Junior Cert, and the majority of these other factors related to mathematics teachers. In addition, the majority of responses attributing the grade received to a mathematics teacher were negative and referred to failure in mathematics as a result of teachers described as "useless", "horrible", "terrible".

Thus, from the findings discussed, students' causal attributions for success/failure in mathematics adhere to Weiner's model, with the possible addition of mathematics teachers. Effort was the main causal attribute, followed by ability, luck and level of difficulty. There was some evidence of a relationship between the causal attributes for success/failure in mathematics chosen by students and their images of mathematics, particularly in terms of the enjoyment of mathematics,

mathematical self-concept and motivation. Finally, the question as to whether gender differences occur – while no statistically significant differences were found for students' genders, a closer examination of the percentages of students selecting the four causal attributes highlighted a link with previous research findings in which males were more likely to attribute success to ability and failure to effort than females, and females were more likely to attribute success to effort and failure to ability than males.

#### **Section 8.2.4: Is there a relationship between 5<sup>th</sup>-year post-primary students' images of mathematics and their prior achievement in mathematics?**

For the 5<sup>th</sup>-year students who took part in our study, prior achievement for these students was examined by considering their Junior Certificate mathematics level and grade. At times during the analysis, the Junior Cert mathematics level and grade were analysed separately, while in other instances they were analysed in combination. With regards to the Junior Certificate mathematics level of students, these are divided into higher level, ordinary level and foundation level. The majority of the students in our sample had taken ordinary level mathematics for the Junior Cert exam – 250 (70.2%) – which is not surprising given all the students in our study were studying ordinary level mathematics for the Leaving Cert course. A total of 95 students (26.7%) had taken the higher level mathematics exam for the Junior Cert while only 8 students had taken foundation level. Due to the low number of foundation level students, for some analyses foundation level was excluded. In the analysis of students' mathematics level, higher level students were found to have the most positive image of mathematics in general and foundation level students were found to have the most negative image of mathematics.

With regards to the grade received by students for the Junior Certificate mathematics exam, these were expressed as Grade A, Grade B, Grade C and Other in our study, where “Other” refers to the lowest grades, which are D, E and F. Examining the mean scores for each of these grades on the image of maths scales, students who received Grade A had the highest means for all scales and therefore can

be said to have the most positive image of mathematics. Students who received the lowest mean scores for the image of maths scales are divided between Grade C and Other. Thus, students with the lowest grades were in general seen to have the most negative image of mathematics. In addition, the differences found between the grade groupings were statistically significant for the enjoyment of mathematics, value of mathematics, mathematical self-concept and combined image of mathematics scales.

Students' images of mathematics was also analysed in relation to their Junior Cert mathematics level and grade combined. In Section 6.5.5 the Mann-Whitney U Test was carried out on the data. The majority of significant differences occurred within the highest and lowest achievement groups; in particular higher level Grade A students had the most positive image of mathematics while ordinary level Other students had the most negative image of mathematics. This is a clear illustration of the relationship between prior achievement in mathematics and students' images of mathematics. This relationship is highlighted further in the ANOVA analyses in Section 6.5.6.2.

One further link between students' prior achievement in mathematics and their current image of mathematics was found in relation to the utility of mathematics or students' utilitarian image of mathematics. From the analysis of Section A Q5 in the questionnaire a weak but significant relationship emerged between students' Junior Certificate mathematics grades and their awareness of the applicability of mathematics to everyday life. I found that students with higher prior achievement in mathematics had a more in-depth appreciation of how mathematics is used in everyday life, providing more varied examples. Students with lower prior achievement in mathematics had a more basic understanding of the utility of mathematics in everyday life or indeed were unaware of the usefulness of mathematics outside school. Students with the lowest prior achievement grades for mathematics were more likely to state that mathematics was not needed outside school or that they disliked mathematics and therefore had no desire to use it.

Consequently, to answer our research question, I conclude that a relationship does exist between 5<sup>th</sup>-year post-primary students' images of mathematics and their prior achievement in mathematics. This relationship emerges most significantly for the highest achievement and lowest achievement students. Students who had previously studied higher level mathematics had the most positive images of mathematics while students who had studied foundation level previously had the most negative images of mathematics, indicating a link between mathematics level and students' images of mathematics. In addition, students with the highest prior achievement in mathematics (i.e., a higher level Grade A) had the most positive images of mathematics, particularly in terms of enjoyment, motivation and self-concept. Students with the lowest prior achievement in mathematics (i.e., an ordinary level Other) had the most negative images of mathematics, particularly in terms of enjoyment and self-concept. The influence of prior achievement can also be seen in students' appreciation of the relevance of mathematics in their daily lives.

### ***Section 8.3: Students' Images of Mathematics***

The nine research question that I have already discussed in this chapter give us an insight into students' images of mathematics with regards to their attitudes, beliefs, motivation, self-concept, emotions, past experiences, causal attributes for success or failure and the factors of influence. Each of the scales used in our study provides some information regarding students' images of mathematics but I have found that some of the scales used do not fit appropriately with each other as hoped. Thus, although the Attitude toward Success in Mathematics Scale and the Mathematics as a Male Domain scale provided some interesting information, particularly the gender differences revealed by the latter scale, the remaining 6 scales provide a better means for examining students' images of mathematics as these 6 scales were found to constitute one factor for students' images of mathematics – see Section 6.5.3. Thus, I would suggest that the Enjoyment of Mathematics Scale, Value of Mathematics Scale, Effectance Motivation in Mathematics Scale, Beliefs about Mathematics Scale, Mathematical Self-concept scale and Anxiety about Mathematics Scale afford the best indication of students' images of mathematics when used in

combination. Although I have included the Beliefs about Mathematics Scale, because of the low reliability found for this scale it may be necessary to obtain an alternative scale for measuring Irish post-primary students' beliefs about mathematics. For the 6 scales remaining as a measure of students' images of mathematics, a positive image of mathematics is indicated by high enjoyment of mathematics, high value of mathematics, high motivation in mathematics, positive beliefs about mathematics, high mathematical self-concept and low anxiety about mathematics. On the other hand, a negative image of mathematics is synonymous with low enjoyment of mathematics, low value of mathematics, low motivation in mathematics, negative beliefs about mathematics, low mathematical self-concept and high anxiety about mathematics.

In answering the research questions, I noted the impact of past experiences of learning mathematics on students' current images of mathematics. It is clear that teachers need to be aware of the possible long-term effects for students who have had negative experiences in mathematics as these negative experiences can have a detrimental effect on students' images of mathematics. Mathematics teachers should also be more aware of their own influence in students' formation of an image of mathematics. In particular, teachers need to make an effort to motivate students, to foster an enjoyment of mathematics in students and to increase students' mathematical self-concept. Parents should also be encouraged to cultivate a positive image of mathematics in students as positive influence from parents was found to have a positive effect on students, particularly in terms of motivation and value of mathematics. Group work in mathematics classes may also provide a means for prompting positive peer influence.

In terms of the various images of mathematics held by students, there was evidence of the five images found by Lim (1999) – the absolutist image, utilitarian image, symbolic image, problem-solving image and enigmatic image – but the most common images of mathematics I found were the utilitarian image, the symbolic image and the problem-solving image.

Firstly, the utilitarian image was to be found in several students' responses to the open-ended questions – see Section 7.7.4.2. Some students held a positive image of mathematics in terms of its usage and relevance. Mathematics was viewed as important in everyday life and necessary for their future. Other students clearly held a negative utilitarian image of mathematics, particularly the mathematics they learn in post-primary school. Several students stated that while they enjoyed studying mathematics that they found relevant, they believed that much of the mathematics taught to them during post-primary education was irrelevant and could not be used outside school. Students were unaware of the applicability to everyday life of the mathematics they were learning or indeed why this mathematics would be needed for any future career. This was expressed by one student who commented that *“the problem is that teachers don't explain what jobs use different topics”*. Students need to understand why they are learning mathematics and to believe in the relevance of mathematics to their own lives and the lives of others. I believe that there is a need for widespread and detailed explanation to students of the relevance of mathematics in a variety of careers, and indeed in their daily lives.

The second image that was frequently found in our study is the symbolic image. Evidence of the symbolic image of mathematics manifested itself in the use of memorisation, rote learning and repetition by students in our study. The symbolic image was mainly a negative image of mathematics for students in our study as there was a clear emphasis on memorising rules and formulae and learning exam questions off by heart. Indeed some students attributed their success in mathematics to their ability to memorise mathematics formulae and questions while other students attributed their failure in mathematics to not memorising the 'right' questions for the exam. This focus on rote-learning has also been witnessed in studies by Eaton & O'Reilly (2009) and Liston & O'Donoghue (2009). This ethos of rote-learning begins in primary school with the reciting of multiplication tables from memory and continues through to post-primary education, with many students relying on their ability to memorise rather than their ability to understand mathematics.

The third image found to be widespread in our study was the problem-solving image of mathematics. This was the most positively expressed image found among students in our sample and responses referring to problem-solving indicated a real enjoyment of mathematics among these students. Students enjoyed being challenged and attempting to solve problems on their own. They felt a sense of accomplishment when solving a new or difficult problem with an obvious effect on their mathematical self-concept. Students referred to various puzzles such as Sudoku and brain-training, as well as applying logic and creating order. Perhaps this problem-solving image of mathematics is the key to improving students' images of mathematics, particularly in terms of enjoyment, self-concept and motivation. I would suggest that by encouraging students to solve problems, either on their own or in groups, students will be motivated to work harder, to understand the mathematics they are learning, to enjoy figuring out how the mathematics works and ultimately have a higher mathematical self-concept. The emphasis on problem-solving in the new Project Maths curriculum in post-primary education provides an ideal opportunity to foster a positive image of mathematics among students.

### ***Section 8.4: Gender Differences in Students' Images of Mathematics***

In my discussion of the research questions in the previous sections of this chapter, I have mentioned gender differences that have occurred in various aspects of students' images of mathematics. Here, I focus entirely on differences between males and females found in our study, the implications of these differences and possible remedies.

Although slightly more females than males participated in our study – 198 females (55.6%) compared to 158 males (44.4%) – students were fairly evenly divided in terms of gender and therefore gender differences that emerged can be deemed as significant and reliable. Gender was seen to play a significant role in two of the scales used in our study; the Mathematics as a Male Domain scale and the Anxiety about Mathematics Scale. Gender was found to make a significant

contribution to the prediction of both of these scales in the multiple regression analysis in Section 6.5.4.

A statistically significant difference was found for the scores of males and females on 6 of the 8 scales used in our questionnaire, as well as for the combined image of maths scale. The most significant differences were again for the Mathematics as a Male Domain scale and the Anxiety about Mathematics Scale with males having a less positive perception of mathematics as a domain for males but lower anxiety levels, while females had a more positive perception of mathematics as a domain for both males and females but higher anxiety levels associated with mathematics. For the other scales, males were found to have a higher enjoyment of mathematics, a more positive value of mathematics, a higher motivation in mathematics, a higher mathematical self-concept and overall a more positive image of mathematics. Females had a significantly lower enjoyment, lower value, were less motivated, had a lower mathematical self-concept and overall a more negative image of mathematics. These findings are consistent with previous research on gender differences in mathematics. Kaiser-Messmer (1993) found that girls had more negative attitudes to mathematics than boys. Forgasz (1995) and Tartre & Fennema (1995) agree that females have less confidence in their ability to learn mathematics than do males. Hannula et al. (2002) also found that girls had lower self-confidence in performing tasks in mathematics than males. Perkins et al. (2007) in their study of PISA results, found that in all countries (including Ireland) except Poland and Serbia, male students reported significantly lower levels of anxiety than female students.

Significant differences were also found between the genders when comparing the co-educational status of schools attended by students. Males attending a single-sex boys' school had the most negative perception of mathematics as a domain for males while females attending a single-sex girls' school had the most positive views of mathematics as a domain for both males and females. Females attending a single-sex girls' school had the highest anxiety levels in mathematics compared with all other students, including females attending a co-educational school. Females



attending a single-sex girls' school also had the lowest mathematical self-concept compared to all other students in our study.

In the literature review, Chapter 2, causal attributions for success or failure in mathematics were found to be one of the major sources of gender differences in mathematics. While students' causal attributions for success/failure in mathematics were not found to be significantly correlated with gender, further analysis of the causal attributions in terms of gender revealed that differences occurred and these were consistent with previous research findings by Fennema (1977) and Pedro et al (1981); see Section 8.2.3. Females were more likely to attribute success in mathematics to effort while males were more likely to attribute success in mathematics to mathematics ability. This has similarities with Soro (2000, 2002) who suggests that girls are seen to succeed because of their diligence, while boys are seen to be talented in mathematics but lacking in effort.

A significant correlation was found between gender of students and their earliest memories in mathematics. In particular, over twice as many females as males recalled negative memories of mathematics and as revealed in Section 8.2.1, a relationship exists between students' past experiences of mathematics and their current images of mathematics. Students who recalled negative memories of mathematics were seen to have the most negative images of mathematics and the increased likelihood of females to recall negative experiences of learning mathematics may have contributed to their more negative image of mathematics.

With regards to the influences on students' images of mathematics, a significant correlation was found with students' gender. One of the most noticeable differences to emerge between the genders regarding mathematical influences was regarding the influence of peers. Females, more than males, acknowledged the influence of peers, either in terms of help, support or encouragement or in terms of competition and comparison. Hill (2008) highlighted the value of social interaction and peer support in a mathematics learning environment and I believe that for females especially, this is important. Maines' (1985) theory that females tend to feel an

increased moral responsibility to family, friends and social aspects of life compared with males may have some relevance here as females are more likely to seek support from and provide encouragement to their peers in mathematics. In our study and in other research studies such as Hill (2008), we have seen the benefits of group work in mathematics class, particularly in terms of enjoyment, motivation and possibly mathematical self-concept. One possible remedy for females' low enjoyment, motivation and self-concept may be in the use of group work for mathematics in post-primary education and the promotion of a learning environment which encourages students to discuss mathematics with their peers.

### ***Section 8.5: Issues Concerning the Current National Interest in Mathematics***

In this section I discuss two issues that are of particular concern to the current national interest in mathematics education. The first relates to the low number of students choosing to study higher level mathematics for the Leaving Certificate. As a considerable portion of our sample had studied higher level mathematics for the Junior Certificate but were now studying ordinary level mathematics for the Leaving Cert, our study provides some insight into the reasons why students are not continuing with higher level mathematics. The second issue relates to Project Maths, the new mathematics curriculum introduced to post-primary students in Ireland. A small minority of students in our sample had been involved with the Project Maths course since entering post-primary education as they were attending Project Maths pilot schools. These students provided a means for comparing students who were accustomed to the Project Maths course with students who were only recently introduced to the new curriculum.

#### **Section 8.5.1: Higher Level v. Ordinary Level**

As previously stated, of the students who took part in our study, 95 (26.7%) had previously studied higher level mathematics for the Junior Certificate examination. Of these 95 students, 9 had achieved a Grade A for mathematics in the Junior Cert, 25 had received a Grade B and 33 received a Grade C. These students,

especially students who had received a Grade A or B, had the highest prior achievement levels in mathematics and yet had discontinued with higher level mathematics upon entering 5<sup>th</sup> year. As the data collection for our study took place between September 2011 and January 2011, students in our sample were in the initial months of the Leaving Cert course and therefore the 95 students who had previously studied higher level mathematics had almost immediately dropped down to ordinary level mathematics in 5<sup>th</sup> year.

Comparing students' images of mathematics, I found that students who had previously studied higher level mathematics tended to have the most positive images of mathematics, and particularly those students who had achieved an A or B grade in the Junior Cert. In particular, higher level Grade A students had significantly higher median scores on the Enjoyment of Mathematics Scale, Value of Mathematics Scale, Effectance Motivation in Mathematics Scale and Mathematical Self-concept scale. In addition, higher level mathematics grades were seen to explain 11% of the variance for the Enjoyment scale, 12% of the variance for the Motivation scale, 14% of the variance for the Value scale and 14% of the variance for the combined image of maths scales. This variance is largely due to the high scores on each of these scales for students with high achievement in higher level mathematics for the Junior Cert. One point I would like to note, however, is that in terms of mathematics anxiety, although these students had the highest prior achievement in mathematics, they did not have the lowest anxiety. Students who had studied ordinary level mathematics for the Junior Cert were found to have the lowest anxiety for all students in our study. In the qualitative data analysis I observed that many students considered higher level mathematics too difficult but ordinary level mathematics quite easy and it is possible that for students who had studied higher level mathematics previously, the level of difficulty had led to increased anxiety levels in mathematics, even for those students who had achieved high grades. On the other hand, for students studying ordinary level which was considered more manageable, the lower level of difficulty had led to less anxiety concerning mathematics, particularly for the large number of students in

our study who had received a Grade A or B for ordinary level mathematics in the Junior Certificate.

Thus, while high prior achievement in higher level mathematics may equal a positive image of mathematics, it does not necessarily indicate low anxiety for these students and I propose that it is perhaps the anxiety associated with studying higher level mathematics that may be partly responsible for students – who had previously studied higher level mathematics for the Junior Cert – deciding to study ordinary level mathematics for the Leaving Cert.

### **Section 8.5.2: Project Maths**

Because of the recent introduction of Project Maths in Irish post-primary education, there is a national interest in gauging students' reactions to the new mathematics curriculum as well as discovering any differences in the image of mathematics held by students who have been studying the Project Maths course in comparison with students who had been studying the old mathematics course until Junior Cert level. In our study, 52 students (14.3% of the sample) were attending schools that had taken part in the piloting of the Project Maths curriculum and therefore these 51 students had been studying Project Maths for the Junior Certificate. The remaining 314 students in our study had been introduced to Project Maths more recently, and therefore these two groups of students provided a preliminary basis for comparing students of the old mathematics curriculum and the new Project Maths curriculum.

In relation to students' images of mathematics, differences were examined for students who had attended a Project Maths pilot school compared with all other students. The only significant difference to emerge in our study was for the Attitude toward Success in Mathematics Scale. Students who had attended a Project Maths pilot school were found to have a slightly more positive attitude to mathematical success.

In the open-ended questions, a number of students referred to Project Maths, particularly in relation to their interest or disinterest in mathematics. While there was some evidence of students reacting positively to the new curriculum: “*Maths is difficult but Project Maths makes it easier*”, references to Project Maths were negative for the most part. Some of the comments made by students regarding Project Maths are outlined in Section 7.7.4.4, with many of these students attributing their current disinterest in mathematics to Project Maths. The comments made by students are indicative of a negative reaction to the change from an old, familiar mathematics course to a new, unfamiliar approach. I have already stated that many students rely on memorising previous exam papers and questions in order to succeed in mathematics, and therefore I suggest that removing students’ ability to rely on memorisation would naturally provoke a negative reaction. In addition, the majority of the students in our study had only recently been introduced to Project Maths, and as yet, the wording of questions may be confusing for students who are unaccustomed to the problem-solving focus of the new curriculum.

Project Maths aims to enhance students’ problem-solving abilities and in our study, students tended to have a positive image of mathematics in terms of problem-solving. Indeed the problem-solving image of mathematics was one of the most widespread images found in Section 7.7.4, with problem-solving seen to be an enjoyable and rewarding experience. Therefore, there is some hope that the introduction of the Project Maths curriculum which is oriented towards problem-solving, may appeal to students’ enjoyment of mathematics in terms of solving problems and being challenged. In my discussion on students’ attitudes to mathematics in Section 8.1.1, I identified the need to raise students’ enjoyment levels in mathematics as a possible means for increasing interest in mathematics and aiding students’ achievement in mathematics. If Project Maths can provide a means for increasing students’ enjoyment, this could have positive consequences for students in terms of achievement and their desire to continue studying mathematics.

## ***Section 8.6: Parents' Occupation***

In the questionnaire distributed to students who participated in our study, an optional question was included asking students to state their parents' occupations. Parents' occupations were classified similarly to the occupation categories in Lim (1999) but an additional category was included for parents who were involved with mathematics in their work. Thus the categories for parents' occupations were: Professional, Technical and Managerial, Skilled, Unskilled and partially skilled, Mathematics, and Others. As this questionnaire item was specified as optional, it received the lowest response rate with only 50.3% of students providing their parent's occupation. Therefore when analysing the categories for parents' occupation, we also compared findings with those for the students who had not provided their parent's occupation.

One of the main reasons for analysing parents' occupations in our study was to discover if students whose parents were involved with mathematics had a more positive image of mathematics. In Section 7.1, it emerged that students whose parents worked with mathematics had the highest medians for enjoyment of mathematics, value of mathematics, attitude toward success in mathematics, mathematics as a male domain, mathematical self-concept and anxiety about mathematics and the highest median score for the overall image of mathematics. This finding indicates that having a parent involved in a mathematics-based career can result in a more positive image of mathematics for students. If parents work with mathematics, it follows that they would have positive images of mathematics and this positive image may be transferred to their children. As well, students with parents who work with mathematics would have an awareness of the importance of mathematics for future careers and this would influence their current image of mathematics. Students in our study were found to acknowledge the influence of parents in mathematics – see Section 8.2.2 – and for students whose parents' occupations involve mathematics, this influence has had a positive effect on their image of mathematics.

## ***Section 8.7 Summary***

Throughout this chapter I have endeavoured to answer the research questions on students' images of mathematics and the influences on students' current images of mathematics. For the most part, findings from our study have supported the theoretical framework I adopted in my attempt to examine Irish 5<sup>th</sup>-year post-primary students' images of mathematics. Students' images of mathematics are seen to be most strongly indicated by their attitudes (enjoyment and value of mathematics), beliefs, motivation, self-concept and emotions. Students' current images of mathematics are influenced by their past experiences of mathematics, by their mathematics teachers, parents and peers and by their prior achievement in mathematics. Gender differences occur for students in their images of mathematics, with males having more positive images of mathematics than females and this is most noticeable with regards to anxiety about mathematics. The sample of students in our study also provided a means for examining differences between students who had previously studied higher level mathematics and students who had studied ordinary level mathematics, thus presenting a means for identifying possible reasons for students' discontinuation with higher level mathematics for the Leaving Cert, with one possible cause found in relation to mathematics anxiety. I also identified implications for Project Maths in terms of students' problem-solving image of mathematics and the potential benefits for students if Project Maths is introduced appropriately to students.

I believe that my study of students' images of mathematics contributes to international research on students' attitudes, beliefs, motivation, self, concept and anxiety regarding mathematics. It also contributes to international research on the impact of past experiences on students' current images of mathematics and the factors influencing students when forming an image of mathematics. My study also contributes to the extensive international research on gender differences in mathematics and adds to the debate on the relationship between prior achievement and students' attitudes, beliefs, motivation, self-concept and anxiety in mathematics.

This is the first study that has examined post-primary students' images of mathematics in Ireland to such an extent. It provides original and essential information to the Irish mathematics education community. I believe that my study contributes to the national interest in post-primary mathematics education by obtaining a view of mathematics education from the students' perspectives and highlighting issues that had been previously found in other countries but not specifically in Ireland. In addition, my study offers some feedback from students on the recently introduced Project Maths curriculum and contributes to the national concern regarding the low numbers of students taking the higher level mathematics course for the Leaving Certificate.



## **Chapter Nine**

### **Conclusions, Recommendations and Future Research**

## **Chapter Nine: Conclusions, Recommendations and Future Research**

In this chapter I provide a summary of my thesis, from the initial review of the literature, through the data collection and analysis to the findings and answering of the research questions. Conclusions drawn from the research findings are outlined. Recommendations for improving students' images of mathematics are made. The theoretical framework for students' images of mathematics is reviewed in light of the findings from my study, and future research to further investigate post-primary students' images of mathematics and other issues that have emerged from this study is discussed.

### ***Section 9.1: Summary of Thesis***

This research study was initiated for a number of reasons, not least of which was my own interest in allowing post-primary students to express their own views and opinions regarding mathematics. Although reports such as the NCCA (2005) Review of Mathematics in Post-Primary Education, the Chief Examiner's Report (2005) and the NCCA (2007) ESRI research into the experiences of students in the third year of junior cycle, highlighted poor attitudes and beliefs among post-primary students, there was no previous study conducted in Ireland that investigated students' images of mathematics by examining students' attitudes, beliefs, motivation, self-concept and emotions about mathematics. In addition, when I began my PhD study, mathematics education in post-primary schools was a topic of national interest as a new mathematics curriculum was being initiated in the form of Project Maths. There was also widespread concern among the Irish mathematics education community regarding the low number of students electing to study higher level mathematics for the Leaving Certificate, with the majority choosing to study ordinary level mathematics, even though many students had previously studied higher level mathematics for the Junior Certificate. It was decided to investigate post-primary students' images of mathematics and to focus on 5<sup>th</sup>-year students specifically. Furthermore, it was decided to investigate the image of mathematics held by ordinary level mathematics students, as this cohort may provide some insight into the reasons

why students were not choosing to study higher level mathematics. This led to the main research aim or research question of this thesis: *“What is the image of mathematics held by 5<sup>th</sup>-year post-primary students in Ireland?”*

A review of the literature of images of mathematics (see Chapter 2) illustrated a lack of a cohesive definition for image of mathematics, with authors using a range of definitions as well as a range of terms such as ‘mathematical identity’ (Eaton & O’Reilly, 2009; Hill, 2008) or ‘affective issues’ (Liston & O’Donoghue, 2007, 2009) to express largely the same concept as ‘image of mathematics’. Whether defined explicitly or implicitly, many researchers appeared to agree that image of mathematics should include attitudes, beliefs, self-concept and anxiety/emotions regarding mathematics and that these elements were related to past experiences of mathematics. This led to my chosen definition for image of mathematics as:

*“A mental representation or view of mathematics, presumably constructed as a result of past experiences, mediated through school, parents, peers or society. This term is also understood broadly to include three domains:*

- The affective domain dealing with attitudes, emotions, and self-concept regarding mathematics and mathematics learning experiences.*
- The cognitive domain dealing with beliefs regarding mathematics and mathematics learning experiences.*
- The conative domain dealing with motivation regarding mathematics and mathematics learning.”*

This definition was chiefly adapted from Lim (1999) and Wilson (2011) as well as influenced by the various research studies that I examined in my literature review (see Chapter 3 for the theoretical framework for my study). A number of research questions arose from the literature review and from my understanding of image of mathematics as follows:

- ❖ *Do 5<sup>th</sup>-year post-primary students in Ireland have a positive or negative attitude toward mathematics?*
- ❖ *What feelings/emotions do 5<sup>th</sup>-year students in Irish post-primary schools associate with mathematics?*
- ❖ *Do 5<sup>th</sup>-year post-primary students in Ireland have confidence in their mathematical ability?*
- ❖ *What beliefs do Irish post-primary 5<sup>th</sup>-year students hold about mathematics?*
- ❖ *Are 5<sup>th</sup>-year post-primary students in Ireland motivated regarding mathematics?*
- ❖ *Do their past experiences of mathematics impact on 5<sup>th</sup>-year post-primary students' current images of mathematics?*
- ❖ *Who influences Irish 5<sup>th</sup>-year post-primary students most in terms of mathematics and the formation of their image of mathematics?*
- ❖ *What are the causal attributions of Irish post-primary students in 5<sup>th</sup>-year for success and/or failure in mathematics and do gender differences occur?*
- ❖ *Is there a relationship between 5<sup>th</sup>-year post-primary students' images of mathematics and their prior achievement in mathematics?*

A questionnaire was drafted (see Chapter 4) that attempted to address these research questions and included both fixed-response items and open-ended questions. The fixed-response items consisted of 8 scales: Enjoyment of Mathematics Scale and Value of Mathematics Scale (Aiken, 1974); Attitude toward Success in Mathematics Scale, Effectance Motivation in Mathematics Scale, Mathematics as a Male Domain scale and Anxiety about Mathematics Scale (Fennema & Sherman, 1976); Mathematical Self-concept scale (Gourgey, 1982); Beliefs about Mathematics Scale (Schoenfeld, 1989). A pilot study was carried out on the drafted questionnaire in early 2011 (see Chapter 5) and after a few minor changes, the final test instrument was distributed and completed by a sample of 356 ordinary level mathematics students in 5<sup>th</sup> year of post-primary school. The questionnaires were entered onto SPSS (version 19) and analysed using SPSS. The constant comparative method of analysis was employed for open-ended questions. The findings from the analysis of the

quantitative and qualitative data were displayed and described in Chapter 6 and Chapter 7. Finally, the findings were discussed in Chapter 8, in particular with reference to the research questions aforementioned.

### **Summary of Findings:**

Findings were interpreted in order to obtain an understanding of students' images of mathematics, their attitudes, beliefs, self-concept, emotions and motivation. Firstly, students' *attitudes* towards mathematics were examined and while students were seen to have generally positive attitudes in terms of the value of mathematics, attitudes in relation to enjoyment of mathematics were generally more negative. The Attitude toward Success in Mathematics Scale was identified as less relevant to understanding students' attitudes to mathematics and this scale was also not a good fit with the combination of scales I used to examine students' images of mathematics. Secondly, for students' *emotions* about mathematics, students with negative emotions were seen to be more widespread and more vocal in expressing these emotions. Feelings of inadequacy, anxiety and frustration were common among students, particularly in relation to negative experiences of mathematics learning. Thirdly, students' mathematical *self-concept* was discussed and it emerged that while some students have high confidence in their ability, other students have a very low self-confidence in mathematics. This confidence is related to students' past experiences of mathematics, and is also influenced by students' prior achievement in mathematics. There also appeared to be a link between mathematical self-concept and the level of mathematics, with some students having low mathematical self-concept regarding higher level mathematics specifically. Fourthly, from examining students' *beliefs* about mathematics, it can be seen that many students believe that mathematics requires memorizing rules and formulae. Some students believe that mathematics requires a natural ability and students with lower achievement in mathematics tend to believe they do not possess this natural ability. The Beliefs about Mathematics Scale used in my study had a very low reliability and therefore it may be necessary to find an alternative Beliefs scale for any future research. In relation to students' beliefs concerning mathematics and gender, male students tended to have more negative

beliefs regarding women and mathematics while females held the more positive beliefs about mathematics as a domain for both males and females. While the Mathematics as a Male Domain scale provided some interesting findings regarding gender differences and the role of women in mathematics, this scale did not combine well with the other scales in my study for investigating students' images of mathematics. Fifthly, students' *motivation* in mathematics was discussed. Students in my sample tended to have a low motivation in mathematics, with students' motivation related to their past experiences, their interest/disinterest in studying mathematics and in particular their prior achievement in mathematics. Students with the highest level of prior achievement had the highest levels of motivation in mathematics.

Students' images of mathematics were also discussed regarding their past experiences of mathematics, their interest or disinterest in mathematics, the factors influencing students' images of mathematics, students' causal attributions for success or failure in mathematics, their prior achievement in mathematics and gender differences. Firstly, students' *past experiences* of mathematics were found to have an impact on their current images of mathematics. Students recalling negative experiences had the most negative images of mathematics while students who recalled positive experiences had the most positive images of mathematics. The majority of students acknowledged that their past experiences of learning mathematics had influenced their current *interest/disinterest* in mathematics, with a subsequent effect on their images of mathematics. Secondly, regarding the *factors of influence* on students' images of mathematics, mathematics teachers, parents and peers were all found to influence students in mathematics and this influence can be seen to have an impact on students' images of mathematics, especially in terms of students' enjoyment of mathematics, value of mathematics, motivation in mathematics and mathematical self-concept. Thirdly, students' *causal attributions* for success or failure in mathematics were examined and each of the elements in Weiner's 1974 model – ability, effort, level of difficulty and luck – were acknowledged by students as contributing to their Junior Cert mathematics grade. In

addition, a number of students cited mathematics teachers as being instrumental in their mathematical success or failure. Effort was the causal attribute most chosen by students as contributing to their mathematics grade. In addition, similarly to previous research studies, males were seen to be more likely to attribute success in mathematics to their ability and failure in mathematics to effort, while females were more likely to attribute success to effort and failure to their ability. Fourthly, a significant relationship was found to exist between students' *prior achievement* in mathematics and their current image of mathematics. The students with the highest prior achievement grades in mathematics had the most positive images of mathematics, especially in relation to their enjoyment, motivation and self-concept. Students with the lowest prior achievement in mathematics had the most negative images of mathematics, particularly for enjoyment of mathematics and mathematical self-concept. Fifthly, *gender differences* were found to exist between students in my study, especially on the Mathematics as a Male Domain scale and the Anxiety about Mathematics Scale. Males had more negative beliefs about women and mathematics, but lower anxiety levels, while females had more positive beliefs about women and mathematics but higher anxiety levels. In addition, females had a significantly lower enjoyment and value of mathematics, were less motivated, had a lower mathematical self-concept and overall a more negative image of mathematics. Another significant finding was that females attending a single-sex girls' school had the highest anxiety levels in mathematics compared with all other students. A link between past experiences and gender also emerged. Over twice as many females as males recalled negative experiences of mathematics, and as previously mentioned, students with negative experiences of mathematics had more negative images of mathematics. Finally, females acknowledged the influence of peers in mathematics more than males, suggesting females are more likely to give support to and seek support from their peers in mathematics.

## **Section 9.2: Conclusions and Contributions**

In this section, specific findings and conclusions from my study are outlined in terms of their contribution to national and/or international mathematics education research and knowledge. While some findings make a significant contribution to international mathematics education research, other findings are more specific to the Irish mathematics education community.

- ***Attitudes towards Mathematics:*** While post-primary students' enjoyment of mathematics and value of mathematics are correlated, they may have low enjoyment levels and yet a high value of mathematics. As students' enjoyment of mathematics was correlated with their interest or disinterest in mathematics, it is clear that students who enjoy mathematics are more likely to be interested in studying mathematics. Students' enjoyment of mathematics was also a stronger indicator of their overall image of mathematics than students' value of mathematics. These findings are significant to both national and international research on attitudes to mathematics, particularly in relation to attitudes and students' engagement with mathematics.
- ***Beliefs about Mathematics:*** There was evidence in this study of the myth that some people possess a natural or innate mathematics ability and some don't, and this myth was particularly common among students with low prior achievement in mathematics. This finding contributes to national and international belief research, indicating the continual presence of the belief that some people have a mathematical mind and some don't. Students in this study also indicated a belief that mathematics requires a good memory and an ability to memorise rules, formulae and even exam questions. This has implications in particular for the Irish mathematics education community as it highlights the continuing reliance on rote-learning, especially in examinations.
- ***Beliefs about Women and Mathematics:*** Male students in this study had quite negative beliefs about women and mathematics, particularly, that men are better at mathematics than women and that certain aspects of mathematics are not suited to females. On the other hand, female students had considerably



more positive beliefs about the role of women in mathematics indicating that females do not feel restricted in mathematics by gender. This conclusion is of interest to mathematics education research both nationally and internationally on gender differences in mathematics, and on the changing role of women in mathematics.

- ***Mathematical Self-Concept:*** There was a strong relationship found between students' mathematical self-concept and their anxiety about mathematics. This contributes to international research on mathematical self-concept and anxiety. It appeared in this study that mathematical self-concept was also linked to the level of mathematics studied by students, with some students indicating a low mathematical self-concept in relation to higher level mathematics, but a high mathematical self-concept in relation to ordinary level mathematics. While this is significant to international research on students' mathematical self-concept, it contributes most significantly to Irish concerns regarding the low number of students taking higher level mathematics for the Leaving Certificate.
- ***Emotions about Mathematics:*** Students who expressed negative emotions about mathematics were more widespread and conveyed their negative feelings about mathematics using emotive and detailed responses. These negative emotions, particularly mathematics anxiety, were linked with past experiences of mathematics and this contributes to the international literature on emotions and anxiety regarding mathematics as well as research on the importance of past experiences. In addition, anxiety was one of the main factors in students' gender differences, with females having significantly higher anxiety levels than males. This finding contributes to the vast international research on gender differences in mathematics.
- ***Motivation in Mathematics:*** Students in my study had a generally low motivation in mathematics, with motivation related to their past experiences of mathematics, their interest or disinterest in mathematics and their prior achievement in mathematics. One of the key findings regarding students' motivation in mathematics was in relation to influence from mathematics

teachers, parents and peers. Influence from teachers, parents and peers was most commonly acknowledged in terms of motivation, with positive influence leading to greater motivation and negative influence leading to less motivation among students. This finding is of interest to the mathematics education community on a national and international level as it highlights the importance of mathematics teachers, parents and peers in motivating students in mathematics, which may have implications for students' engagement with mathematics.

- ***Past Experiences of Mathematics:*** The majority of students' recollections of learning mathematics related to negative experiences – 53%, compared with 24% relating to positive experiences. Students recalling negative experiences or memories of learning mathematics had the most negative images of mathematics while students who recalled positive memories of mathematics had the most positive images of mathematics. This finding contributes to international research on past experiences of learning mathematics and highlights the impact of past experiences on students' current images of mathematics.
- ***Students' Interest or Disinterest in Mathematics:*** The majority of students – 72.8% - agreed that their past experiences of mathematics had caused them to be either interested or disinterested in mathematics. Nearly twice as many students were found to be disinterested in mathematics than were interested, 50.9% compared to 26.1%. Students' reasons for interest or disinterest with mathematics had a significant correlation with students' enjoyment of mathematics, value of mathematics, motivation in mathematics, beliefs about mathematics, anxiety about mathematics and their overall image of mathematics. This finding contributes to international research on past experiences of mathematics as well as the relationship between mathematical interest and image of mathematics. This finding also has particular significance for the Irish mathematics education community as it contributes to the national concern regarding students' engagement with mathematics.

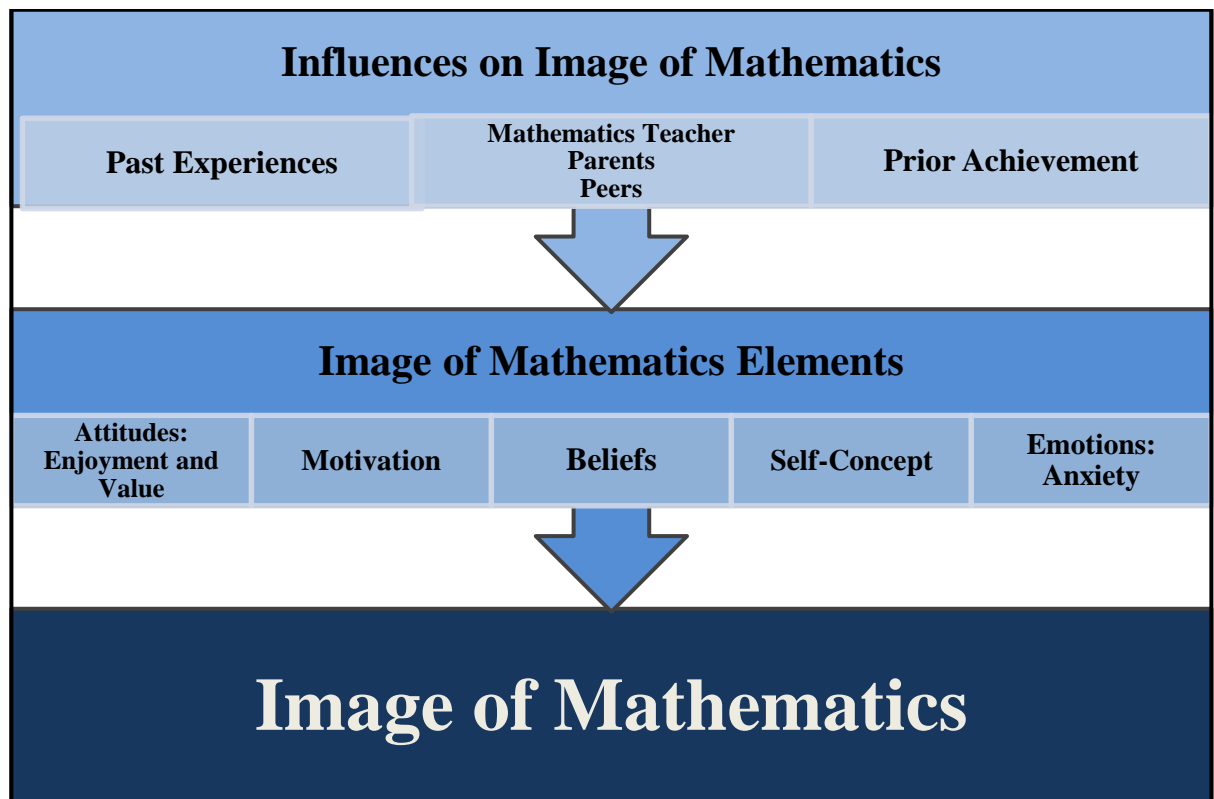
- ***Influence from Mathematics Teachers:*** Mathematics teachers were found to be the greatest influence on students and furthermore, 28.9% of the sample believed that their mathematics teacher was the only possible influence in mathematics as he/she is the person teaching them mathematics. This contributes to both national and international mathematics education, having particular importance for mathematics teacher education as it highlights the influence of teachers on their students.
- ***Influence from Parents:*** Influence from parents or other family members was the second greatest influence on students. Fathers were most commonly cited as helping students in understanding mathematics, while both parents provided support and encouragement. A relationship emerged between parental influence and students' value of mathematics as many students, referring to influence from parents, stated that their parents believed that mathematics was an important subject for future study and careers. This is significant to international mathematics education research as it highlights a differentiation between the roles of fathers and mothers as influences in mathematics and also signifies a link between parents' value of mathematics and students' value of mathematics.
- ***Influence from Peers:*** Females were more likely to acknowledge the influence of peers than males were and for the most part this influence was positive, with students motivated to do as well as or even better than peers. This may support the use of group work in mathematics classes and therefore is of interest to mathematics educators both nationally and internationally. It also contributes to research on gender differences in mathematics.
- ***Causal Attributes for Success and/or Failure in Mathematics:*** Males were more likely to attribute success in mathematics to mathematics ability and failure in mathematics to lack of effort, while females were more likely to attribute success to effort and failure to mathematics ability. This contributes to international research on gender differences in mathematics.
- ***Prior Achievement in Mathematics:*** There is a significant relationship between students' prior achievement in mathematics and their image of

mathematics and this relationship is most significant at the extremes, i.e. the highest levels of prior achievement and the lowest levels of prior achievement. Students with the highest prior achievement in mathematics had the most positive images of mathematics, while students with the lowest prior achievement in mathematics had the most negative images of mathematics. This contributes to international debate on achievement in mathematics. While the main debate between researchers is whether achievement influences or is influenced by attitudes to mathematics, this study shows that prior achievement clearly has an effect on students' current images of mathematics.

- **Higher Level Mathematics:** Students who had previously studied higher level mathematics for the Junior Certificate had the most positive images of mathematics. However, students who had studied higher level mathematics had a higher anxiety level regarding mathematics than ordinary level students. This finding contributes to the current national interest in Leaving Certificate higher level mathematics as it may suggest a reason for the low number of students continuing with higher level mathematics for the Leaving Cert.
- **Project Maths:** For students in this study, Project Maths was more commonly cited as contributing to their current disinterest in mathematics than their interest and this must be taken into account by the Irish mathematics education community and particularly the Project Maths committee. On the other hand, students in this study showed a positive image of mathematics in terms of problem-solving, with the 'problem-solving image' found to be one of the most common and most positive images of mathematics among students. This also has implications for Project Maths which promotes problem-solving in the new mathematics curriculum and it also contributes to Irish and international mathematics education research on students' images of mathematics.

### **Section 9.3: Image of Mathematics Model**

Based on the analysis of the quantitative and qualitative data and as a result of the findings that emerged from my study on post-primary students' images of mathematics, I recommend some changes to our original model for investigating students' images of mathematics. The new model for students' images of mathematics is displayed in Figure 9.1.



**Figure 9.1: Image of Mathematics Model**

This new model shows that the elements incorporated in image of mathematics are attitudes toward mathematics (enjoyment and value), motivation in mathematics, beliefs about mathematics, mathematical self-concept and emotions about mathematics (anxiety). Figure 9.1 shows that these elements are influenced by past experiences of mathematics, by mathematics teachers, parents and peers, and by prior achievement in mathematics. This new model is based on my findings from this PhD study and brings together the relationship between past experiences,

mathematical influences, prior achievement, attitudes, beliefs, motivation, self-concept and emotions in forming an image of mathematics.

### ***Section 9.4: Recommendations***

In this section I suggest some recommendations based on the findings from my research:

- In my review of the related literature (Chapter 2) it became clear that there was no universal definition for ‘image of mathematics’, with many researchers giving no explicit definition of image of mathematics in their work. Also apparent, was the debate and confusion among researchers within mathematics education regarding the theoretical understanding of attitudes and beliefs. There is clearly a need for a more explicit and consistent definition of ‘image of mathematics’. Improved communication and acknowledgement within the mathematics education community is also required with regards to attitudes and beliefs, with a move to forming a more cohesive theoretical framework.
- Due to the low reliability found for Schoenfeld’s (1989) Beliefs about Mathematics Scale in my study as well as in another study carried out in Ireland (Liston, 2009), there is clearly a need to develop or adapt a scale that will reliably measure Irish students’ beliefs about mathematics. Beliefs form an integral part of students’ images of mathematics and without a reliable form of assessing students’ beliefs about mathematics, we leave a vital aspect of students’ images of mathematics without an appropriate evaluation.
- Based on my findings, there is clearly a need to increase students’ enjoyment of mathematics, to dispel negative beliefs (such as lacking natural mathematics ability), to increase motivation in students, to encourage students’ mathematical self-concept and to lower students’ anxiety levels regarding mathematics. From my study, it is clear that mathematics teachers have a significant influence on their students with regards to each of these

aspects of students' images of mathematics. Mathematics teachers need to be aware of their influence on students with regards to students' attitudes, beliefs, motivation, self-concept and anxiety and to attempt to nurture a positive image of mathematics among students.

- Due to the positive influence from peers reported by students in my study, there may be a need to encourage peer interaction within mathematics classes as a means for improving students' enjoyment levels and motivation. I would suggest introducing some group activities within mathematics classes allowing students to work together to solve problems, help each other and create an atmosphere of support and encouragement within the classroom.
- Students in my study expressed a desire to understand the relevance of the mathematics they are learning. With many students unaware of the applicability of mathematics to their daily lives, future careers and further education, I suggest that mathematics teachers need to explain to students the relevance of mathematics outside school. Perhaps it would be useful to discuss with students when and where the various mathematics topics can be employed or to develop a pamphlet that discussed mathematics in relation to various careers and further education options and to distribute this pamphlet to post-primary students.
- Mathematics teachers and the mathematics education community as a whole should be aware of the findings of this study with regards to students taking higher level mathematics and increased anxiety regarding mathematics. Although further research is required on this issue, the possibility of a relationship between studying higher level mathematics and high mathematics anxiety may explain to some degree the low number of students taking higher level mathematics for the Leaving Cert. As such, there would clearly be the need for mathematics teachers to be aware of this increased anxiety and for the mathematics education community to find a means for alleviating some of this anxiety without reducing the level of mathematics studied.

## ***Section 9.5: Future Research***

The findings from this study highlighted six of the eight scales used as a good combination for examining students' images of mathematics – see Section 8.3. Therefore, future research may be performed using six rather than eight scales in order to measure students' images of mathematics. Future research would also be required to test the new theoretical model for 'image of mathematics' that was proposed in Section 9.3 as a result of the findings from this study.

Due to the lack of resources, time and money, this study was not conducted on as large a scale as other national studies such as the NCCA (2007) study carried out on 3<sup>rd</sup>-year students' attitudes. There is a need for future research to be conducted on a larger scale of post-primary students' images of mathematics, with perhaps more qualitative methods of research included, as the qualitative data proved to be invaluable in providing an insight into students' images of mathematics.

With the future research on students' images of mathematics could be included the development of a scale to measure Irish post-primary students' beliefs about mathematics. There is a need to find an appropriate and reliable scale for assessing students' beliefs about mathematics, perhaps one which reflects the beliefs found to exist among students in this study regarding innate mathematical ability and rote-learning.

The findings from this study regarding students who had previously studied higher level mathematics but were now studying ordinary level mathematics provided some interesting information not originally expected from this study. There is a need for a specific research study in order to investigate the possible reasons for students' reluctance to study higher level Leaving Cert mathematics, especially those students who had performed well in higher level Junior Cert mathematics. In particular future research is required to investigate the possible relationship we found in this study between studying higher level mathematics and increased anxiety about mathematics.



## **Appendices**



## Student Questionnaire

An Investigation into the Image of Mathematics held by Post-primary Students in Ireland

- *Please answer all questions truthfully and to the fullest extent.*
- *You are required to give your name but no individual student will be identified in the final report.*
- *All information will be kept confidentially and only used for this study.*
- *Your school/teacher will not have access to your questionnaire answers.*

### **Student Profile:**

*Please **tick** the appropriate answer in the questions with an option given.*

**Name:**

**Gender:**      Male ☐

Female ☐

**Age:**

**Parent(s) Occupation (Optional):**

**Post-primary School Attending:**

Single-sex boys ☐

Single-sex girls ☐

Co-educational ☐

**Junior Certificate Mathematics Level:**

Higher Level ☐

Ordinary Level ☐

Foundation ☐

**Junior Certificate Mathematics Grade:**

A ☐

B ☐

C ☐

Other \_\_\_\_\_

**Section A:**

*Please answer each of these questions in as much detail as you can. It is important that you answer as honestly as you can. These questions are about your past experiences of mathematics. There are no right or wrong answers.*

**1. What is your earliest memory of studying mathematics?**

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**2. Have your experiences of mathematics caused you to be interested/disinterested in mathematics?**

Yes ☐

No ☐

**Please explain.**

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**3. Who influences you the most in mathematics? (Can be more than one person)**

Mathematics Teacher ☐

Parent(s) ☐

Peers ☐

Media ☐

Other \_\_\_\_\_

**Why?**

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**4. Which of the following contributed most to the grade you received for mathematics in the Junior Certificate:**

Mathematics Ability ☐

Effort ☐

Luck ☐

Level of Difficulty of Exam ☐

Other \_\_\_\_\_

**Please explain.**

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**5. Do you use Mathematics outside of school and school work?**

Yes ☐

No ☐

**If so please give examples. If not, please give reasons.**

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## **Section B:**

*For each statement, please **tick** the box which best describes what you think or feel.*

**1 = strongly disagree , 2 = disagree, 3 = unsure, 4 = agree, 5 = strongly agree**

1. Mathematics makes me feel uneasy and  
confused. 1 ☐ 2 ☐ 3 ☐ 4 ☐ 5 ☐
2. I have always enjoyed studying mathematics  
at school. 1 ☐ 2 ☐ 3 ☐ 4 ☐ 5 ☐
3. I am interested and willing to acquire further  
knowledge of mathematics. 1 ☐ 2 ☐ 3 ☐ 4 ☐ 5 ☐
4. Mathematics has contributed greatly to science  
and other fields of knowledge. 1 ☐ 2 ☐ 3 ☐ 4 ☐ 5 ☐
5. Mathematics is a very worthwhile and  
necessary subject. 1 ☐ 2 ☐ 3 ☐ 4 ☐ 5 ☐
6. Mathematics is not important in everyday  
life. 1 ☐ 2 ☐ 3 ☐ 4 ☐ 5 ☐
7. There is nothing creative about mathematics;  
it's just memorizing formulas and  
things. 1 ☐ 2 ☐ 3 ☐ 4 ☐ 5 ☐
8. I'd be happy to get top grades in  
mathematics. 1 ☐ 2 ☐ 3 ☐ 4 ☐ 5 ☐
9. Being regarded as smart in mathematics  
would be a great thing. 1 ☐ 2 ☐ 3 ☐ 4 ☐ 5 ☐
10. If I had good grades in mathematics, I  
would try to hide it. 1 ☐ 2 ☐ 3 ☐ 4 ☐ 5 ☐
11. I don't like people to think I'm smart in  
mathematics. 1 ☐ 2 ☐ 3 ☐ 4 ☐ 5 ☐

12. When a mathematics problem arises that I  
can't immediately solve, I stick with it until  
I have the solution. 1 ☐ 2 ☐ 3 ☐ 4 ☐ 5 ☐
13. I am challenged by mathematics problems  
I can't understand immediately. 1 ☐ 2 ☐ 3 ☐ 4 ☐ 5 ☐
14. Mathematics puzzles are boring. 1 ☐ 2 ☐ 3 ☐ 4 ☐ 5 ☐
15. I do as little work in mathematics as  
possible. 1 ☐ 2 ☐ 3 ☐ 4 ☐ 5 ☐
16. Mathematics problems can be done correctly  
in only one way. 1 ☐ 2 ☐ 3 ☐ 4 ☐ 5 ☐
17. The best way to do well in mathematics  
is to memorize all the formulas. 1 ☐ 2 ☐ 3 ☐ 4 ☐ 5 ☐
18. I would trust a woman just as much as I  
would trust a man to figure out important  
calculations. 1 ☐ 2 ☐ 3 ☐ 4 ☐ 5 ☐
19. Women certainly are logical enough to  
do well in mathematics. 1 ☐ 2 ☐ 3 ☐ 4 ☐ 5 ☐
20. I would have more faith in the answer for  
a mathematics problem solved by a man  
than a woman. 1 ☐ 2 ☐ 3 ☐ 4 ☐ 5 ☐
21. I would expect a woman mathematician to  
be a masculine type of person. 1 ☐ 2 ☐ 3 ☐ 4 ☐ 5 ☐
22. I don't ask questions in mathematics classes  
because mine sound stupid. 1 ☐ 2 ☐ 3 ☐ 4 ☐ 5 ☐
23. Whenever I do a mathematics problem, I  
am sure that I have made a mistake. 1 ☐ 2 ☐ 3 ☐ 4 ☐ 5 ☐
24. I can understand mathematics better than  
most people. 1 ☐ 2 ☐ 3 ☐ 4 ☐ 5 ☐
25. When I do mathematics, I feel confident  
that I have done it correctly. 1 ☐ 2 ☐ 3 ☐ 4 ☐ 5 ☐

26. I haven't usually worried about being able  
to solve mathematics problems.      1 ☐    2 ☐    3 ☐    4 ☐    5 ☐
27. I usually have been at ease in mathematics  
classes.      1 ☐    2 ☐    3 ☐    4 ☐    5 ☐
28. I get a sinking feeling when I think of  
trying hard mathematics problems.      1 ☐    2 ☐    3 ☐    4 ☐    5 ☐
29. I am interested and willing to use mathematics  
outside school and on the job.      1 ☐    2 ☐    3 ☐    4 ☐    5 ☐
30. Mathematics makes me feel uncomfortable  
and nervous.      1 ☐    2 ☐    3 ☐    4 ☐    5 ☐
31. Mathematics is less important to people  
than art or literature.      1 ☐    2 ☐    3 ☐    4 ☐    5 ☐
32. Mathematics helps develop a person's mind  
and teaches him to think.      1 ☐    2 ☐    3 ☐    4 ☐    5 ☐
33. It would make me happy to be recognized  
as an excellent student in mathematics.      1 ☐    2 ☐    3 ☐    4 ☐    5 ☐
34. Being first in a mathematics competition  
would make me pleased.      1 ☐    2 ☐    3 ☐    4 ☐    5 ☐
35. If I got the highest grade in mathematics  
I'd prefer no one knew.      1 ☐    2 ☐    3 ☐    4 ☐    5 ☐
36. Mathematics is enjoyable and stimulating  
to me.      1 ☐    2 ☐    3 ☐    4 ☐    5 ☐
37. Figuring out mathematical problems does  
not appeal to me.      1 ☐    2 ☐    3 ☐    4 ☐    5 ☐
38. I would rather have someone give me the  
solution to a difficult problem than to have  
to work it out for myself.      1 ☐    2 ☐    3 ☐    4 ☐    5 ☐
39. Real mathematics problems can be solved  
by common sense instead of the mathematics  
rules you learn in school.      1 ☐    2 ☐    3 ☐    4 ☐    5 ☐



40. Studying mathematics is just as appropriate  
for women as for men. 1 ☐ 2 ☐ 3 ☐ 4 ☐ 5 ☐
41. It's hard to believe a female could be a  
genius in mathematics. 1 ☐ 2 ☐ 3 ☐ 4 ☐ 5 ☐
42. Mathematics is for men; arithmetic is for  
women. 1 ☐ 2 ☐ 3 ☐ 4 ☐ 5 ☐
43. I have never been able to think  
mathematically. 1 ☐ 2 ☐ 3 ☐ 4 ☐ 5 ☐
44. I have a good mind for mathematics. 1 ☐ 2 ☐ 3 ☐ 4 ☐ 5 ☐
45. Mathematics doesn't scare me at all. 1 ☐ 2 ☐ 3 ☐ 4 ☐ 5 ☐
46. I usually have been at ease during  
mathematics tests. 1 ☐ 2 ☐ 3 ☐ 4 ☐ 5 ☐
47. My mind goes blank and I am unable  
to think clearly when working  
mathematics. 1 ☐ 2 ☐ 3 ☐ 4 ☐ 5 ☐
48. Mathematics is dull and boring because it  
leaves no room for personal opinion. 1 ☐ 2 ☐ 3 ☐ 4 ☐ 5 ☐
49. An understanding of mathematics is needed  
by artists and writers as well as  
scientists. 1 ☐ 2 ☐ 3 ☐ 4 ☐ 5 ☐
50. I'd be proud to be the outstanding student  
in mathematics. 1 ☐ 2 ☐ 3 ☐ 4 ☐ 5 ☐
51. People would think I was a 'swot' if I got  
A's in mathematics. 1 ☐ 2 ☐ 3 ☐ 4 ☐ 5 ☐
52. Once I start trying to work on a mathematics  
puzzle, I find it hard to stop. 1 ☐ 2 ☐ 3 ☐ 4 ☐ 5 ☐
53. I don't understand how some people can  
spend so much time on mathematics and  
seem to enjoy it. 1 ☐ 2 ☐ 3 ☐ 4 ☐ 5 ☐

54. To solve mathematics problems you have  
to be taught the right procedure, or you  
can't do anything. 1 ☐ 2 ☐ 3 ☐ 4 ☐ 5 ☐
55. Males are not naturally better than females  
in mathematics. 1 ☐ 2 ☐ 3 ☐ 4 ☐ 5 ☐
56. It takes me much longer to understand  
mathematical concepts than the average  
person. 1 ☐ 2 ☐ 3 ☐ 4 ☐ 5 ☐
57. I have never felt myself incapable of  
learning mathematics. 1 ☐ 2 ☐ 3 ☐ 4 ☐ 5 ☐
58. It wouldn't bother me at all to take more  
mathematics classes. 1 ☐ 2 ☐ 3 ☐ 4 ☐ 5 ☐
59. Mathematics makes me feel uncomfortable,  
restless, irritable, and impatient. 1 ☐ 2 ☐ 3 ☐ 4 ☐ 5 ☐
60. I have never liked mathematics, and  
it is my most dreaded subject. 1 ☐ 2 ☐ 3 ☐ 4 ☐ 5 ☐
61. Mathematics is not important for the  
advance of civilization and society. 1 ☐ 2 ☐ 3 ☐ 4 ☐ 5 ☐
62. It would be really great to win a prize  
in mathematics. 1 ☐ 2 ☐ 3 ☐ 4 ☐ 5 ☐
63. I like mathematics puzzles. 1 ☐ 2 ☐ 3 ☐ 4 ☐ 5 ☐
64. Everything important about mathematics  
is already known by mathematicians. 1 ☐ 2 ☐ 3 ☐ 4 ☐ 5 ☐
65. Girls can do just as well as boys in  
mathematics. 1 ☐ 2 ☐ 3 ☐ 4 ☐ 5 ☐
66. If I can understand a mathematics problem,  
then it must be an easy one. 1 ☐ 2 ☐ 3 ☐ 4 ☐ 5 ☐
67. When I have difficulty with mathematics,  
I know I can handle it if I try. 1 ☐ 2 ☐ 3 ☐ 4 ☐ 5 ☐
68. A mathematics test would scare me. 1 ☐ 2 ☐ 3 ☐ 4 ☐ 5 ☐

69. Mathematics is very interesting, and I have usually enjoyed classes in this subject. 1 ☐ 2 ☐ 3 ☐ 4 ☐ 5 ☐
70. Winning a prize in mathematics would make me feel unpleasantly conspicuous. 1 ☐ 2 ☐ 3 ☐ 4 ☐ 5 ☐
71. The challenge of mathematics problems does not appeal to me. 1 ☐ 2 ☐ 3 ☐ 4 ☐ 5 ☐
72. When a woman has to solve a mathematics problem, it is feminine to ask a man for help. 1 ☐ 2 ☐ 3 ☐ 4 ☐ 5 ☐
73. I have no more trouble understanding mathematics than any other subject. 1 ☐ 2 ☐ 3 ☐ 4 ☐ 5 ☐
74. I enjoy going beyond the assigned work and trying to solve new problems in mathematics. 1 ☐ 2 ☐ 3 ☐ 4 ☐ 5 ☐
75. Mathematics is needed in order to keep the world running. 1 ☐ 2 ☐ 3 ☐ 4 ☐ 5 ☐
76. In mathematics you can be creative and discover things for yourself. 1 ☐ 2 ☐ 3 ☐ 4 ☐ 5 ☐
77. I don't have a good enough memory to learn mathematics. 1 ☐ 2 ☐ 3 ☐ 4 ☐ 5 ☐
78. I would like to develop my mathematical skills and study this subject more. 1 ☐ 2 ☐ 3 ☐ 4 ☐ 5 ☐
79. When a question is left unanswered in mathematics class, I continue to think about it afterward. 1 ☐ 2 ☐ 3 ☐ 4 ☐ 5 ☐
80. I almost never have become distressed during a mathematics test. 1 ☐ 2 ☐ 3 ☐ 4 ☐ 5 ☐
81. It would make people like me less if I were a really good mathematics student. 1 ☐ 2 ☐ 3 ☐ 4 ☐ 5 ☐

82. Girls who enjoy studying mathematics

are a bit peculiar.

1 ☐

2 ☐

3 ☐

4 ☐

5 ☐

83. Mathematics is needed in designing

practically everything.

1 ☐

2 ☐

3 ☐

4 ☐

5 ☐

84. Females are as good as males in

geometry.

1 ☐

2 ☐

3 ☐

4 ☐

5 ☐

## **Appendix B**



### **Cover Letter**

Dear Sir/Madam,

I am writing to you to invite your school to take part in a research project that forms part of my PhD in Mathematics in University College Cork. This research will investigate the image of mathematics held by post-primary school students in Ireland. The study focuses on 5<sup>th</sup>-year students and their attitudes, beliefs and emotions regarding mathematics. The study will help us to better understand the image of mathematics in Irish schools and will contribute greatly to mathematics education research both nationally and internationally.

Your school has been selected randomly from a list of all Irish post-primary schools. This selection was made using a statistically rigorous procedure.

I would really appreciate it if you could take the time to assist with this study. The study involves the completion of a questionnaire on students' attitudes, beliefs, emotions and past experiences regarding mathematics, and a possible follow-up interview at a later stage. Ideally, I could organize this with a mathematics teacher at your school who could distribute the questionnaires to 20 of your 5<sup>th</sup>-year students. An Informed Consent form will be issued to participating students to be signed by both the student and a parent/guardian before completing the questionnaire. Completion of the questionnaire should not exceed 30 minutes.

No risks are involved in this study. All information gathered will remain confidential and will be used only for the purpose of this research project. The students will not be required to attach their names to the questionnaires and all information will be stored securely with access available only to me and my PhD supervisor.

Your co-operation and participation in this study will be much appreciated and gratefully acknowledged in the final PhD thesis. It is hoped that this study will be of significant benefit to mathematics teaching and learning in post-primary education

If you would like your school to be involved in this study or if you have any questions about this study you are welcome to contact me at any time at the address above, by email or by telephone. You can also contact my PhD supervisor Professor Martin Stynes at the same address or by email or telephone.

Kind regards

Ciara Lane



## ***Appendix C***

### **Debrief Letter**

Dear Sir/Madam,

I would like to thank your school, for taking part in the recent survey for my PhD research.

The aim of this research is to discover the image of mathematics held by post-primary school students in Ireland. This includes examining their attitudes to mathematics, beliefs and emotions about mathematics and their past experiences of mathematics. Students who have taken part in this study will help us to better understand the image of mathematics in Irish schools, which will contribute greatly to mathematics education research both nationally and internationally.

If you or any of the participating students at your school have comments or questions about the study please feel free to contact me at the above address, by email or by telephone.

Thank you again for your assistance.

Yours sincerely,

Ciara Lane

## ***Appendix D***

### **Parent/Guardian Information Sheet**

#### **Title of Project:**

An Investigation into The Image of Mathematics held by Post-primary Students in Ireland

#### **Purpose of the study:**

As part of the requirements for a PhD (doctorate) in Mathematics at UCC, I am carrying out a research study. The study is concerned with the images of mathematics held by 5<sup>th</sup>-year students in Irish post-primary schools. It will examine these students' attitudes to, beliefs and emotions about, and past experiences of mathematics. A number of questions will ask your child to make a personal judgment about how she/he feels about mathematics and a self-evaluation of his/her experience of learning mathematics. The questionnaire also asks students some basic background information which have been deemed important in assessing the results from the study, however all information supplied is voluntary and your child is under no obligation to answer any of these questions (in particular the question on parental occupation is optional). The study will help us to better understand the image of mathematics in Irish schools and will benefit greatly mathematics education research both nationally and internationally.

#### **Participation Information:**

- Your child has been asked to take part in this study as his/her school has been randomly selected to participate from a list of all Irish post-primary schools. This selection was made using a statistically rigorous procedure.
- The study will involve completing a questionnaire which will take place in school, during school hours, and at a fixed time and date, as arranged by the Principal/mathematics teachers. Both the Principal and mathematics teacher have been informed that no penalty or incentive applies to students' participation. Completion of the questionnaire should not exceed 30 minutes. Your child may also be asked to take part in an interview at some later stage when all the questionnaires have been returned to the researcher.
- There are no risks involved in this study. All information gathered will remain confidential and will be used only for the purpose of this study. Students are required to attach their name to the questionnaire; however no individual student will be identified in the final report. The information gathered will be stored securely with access only available to me and my PhD supervisor.
- Your child is under no obligation to participate in this study. He/she has the option of withdrawing from the study at any stage. If you have any questions please do not hesitate to contact me and I will clarify any issues that you are concerned about.



## Informed Consent Form

### **Title of Project:**

An Investigation into The Image of Mathematics held by Post-primary Students in Ireland

Your child is under **no** obligation to participate in this study. If they agree to participate, but at a later stage feel the need to withdraw, they are free to do so. It will not affect them in any way.

***Please answer all of the following (tick the appropriate box):***

I have read and understood the information sheet. Yes ☐ No ☐

I understand what the study is about, and what the results will be used for. Yes ☐ No ☐

I am fully aware of all the procedures involving my child. Yes ☐ No ☐

I know that my child's participation is voluntary and that they can withdraw from the project at any stage without giving any reason. Yes ☐ No ☐

I understand that my child's data will be kept confidential. Yes ☐ No ☐

**I agree to participate in the above study**

**Signature of Participant:** \_\_\_\_\_ **Date:** \_\_\_\_\_

**Signature of Parent/Guardian:** \_\_\_\_\_ **Date:** \_\_\_\_\_

**Signature of Researcher:** \_\_\_\_\_ **Date:** \_\_\_\_\_



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